ICE FUEL:
A REGENERATIVE ICE ENERGY EDUCATION PARK
ON A POST-INDUSTRIAL SITE

A CREATIVE PROJECT
SUBMITTED TO THE GRADUATE SCHOOL
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE
MASTER OF LANDSCAPE ARCHITECTURE

BY

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Abstract

This project reclaims the local rich history of ice harvesting as a heritage event and utilizes the existing relic storage infrastructure of fuel tanks and slag, which are both abundant resources. The reintroduced ice industry provides multifaceted and integrated benefits for the region including cooling energy, water purification, cultural heritage, recreation and wellness, community connection, and economic resilience.

The regenerative seasonal cooling system removes polluted ice from the nearby lake in addition to collecting stormwater runoff from the community for on-site ice harvesting. The ice bounty is transported to the ice fuel storage plant, employing an adaptive reuse strategy for existing derelict fuel tanks and slag. The ice storage provides much needed cooling benefits for the site and the local community. As the ice melts, the water combined with community and site runoff will be purified in a series of surface wetlands on the site. Part of the purified water supports on-site consumption, such as community food production, entertainment and ice production. The rest of the water eventually returns to the original lake. Thus the whole system achieves self- sufficiency while incrementally improving the overall water quality. Thus, a strategy of introducing a regenerative seasonal cooling system to drive ecological reclamation and education, entertainment and production development is established.

Taking the site as a prototype, this strategy has the flexibility to be applied into communities and larger urban fabric in areas challenged by similar climates. Through implementing the seasonal ice cooling system on vacant lots, those abandoned lands will be transformed into district cooling generators, distributing needed cooling and water resources to benefit local community entertainment, production and education systems.

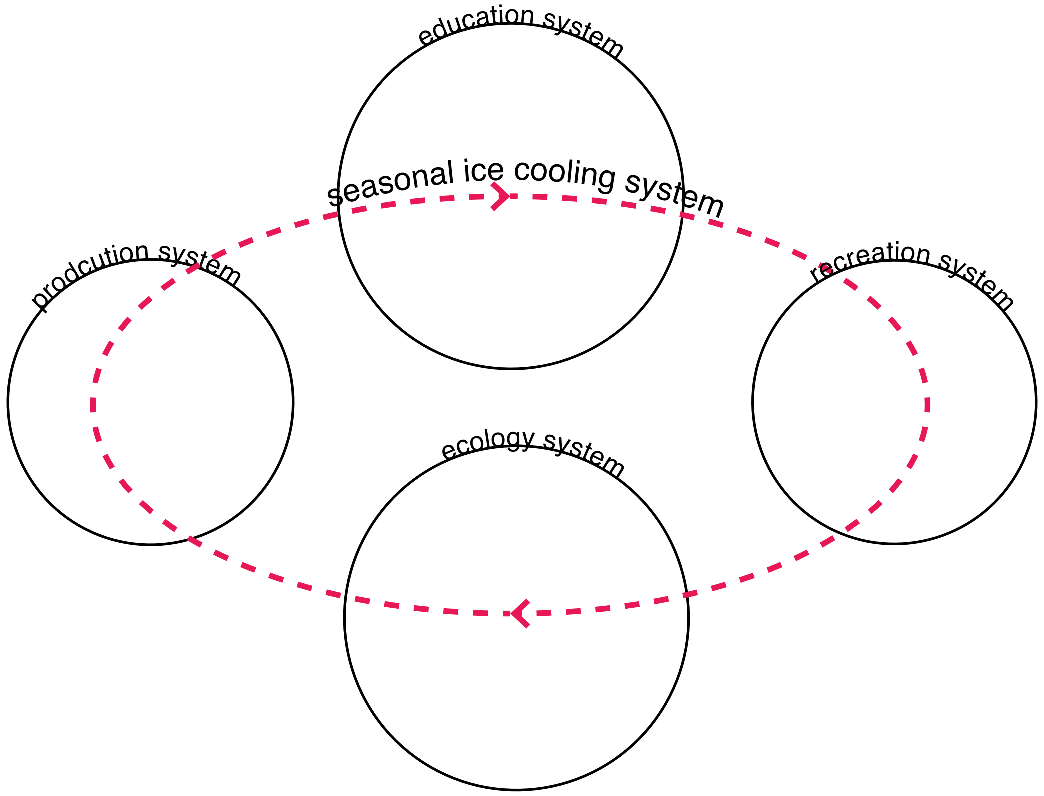

Figure 0.00 Site system framework

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RESEARCH INTRODUCTION

MAIN QUESTION:

How to apply a regenerative seasonal nature ice cooling system on a post-industrial brownfield site that provides recreation, production and education benefits to surrounding communities?

SUB QUESTIONS:

1.What is a regenerative seasonal nature ice cooling system?

1.1 What are the advantages of a seasonal ice cooling system compared with a conventional cooling system?

1.2 How to develop the nature ice cooling system?

2. How to redevelop a post-industrial brownfield?

2.1 What are the design considerations in a brownfield project?

3. How to integrate the regenerative seasonal nature of the ice cooling system with the brownfield redevelopment ?

4. How can an Ice Fuel project be a prototype to influence district-cooling system developments.

SIGNIFICANCE

This project integrates the harvesting of ice fuel layers as a renewable industry and as an opportunity to create an education park in the heart of an industrial corridor in the northwest Indiana. It seeks to create a symbiotic relationship among sustainable energy production, regional education and recreation integrated with a systematic structure for Ice Fuel design.

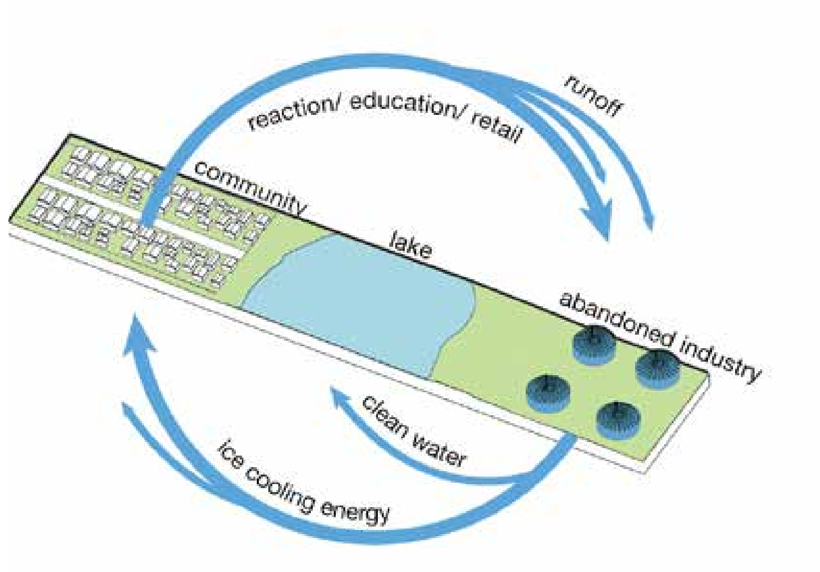


Figure 0.01 regenerative cooling system relies on water and winter temperature to generate cooling and clean water that benefits local community entertainment, production and education systems.

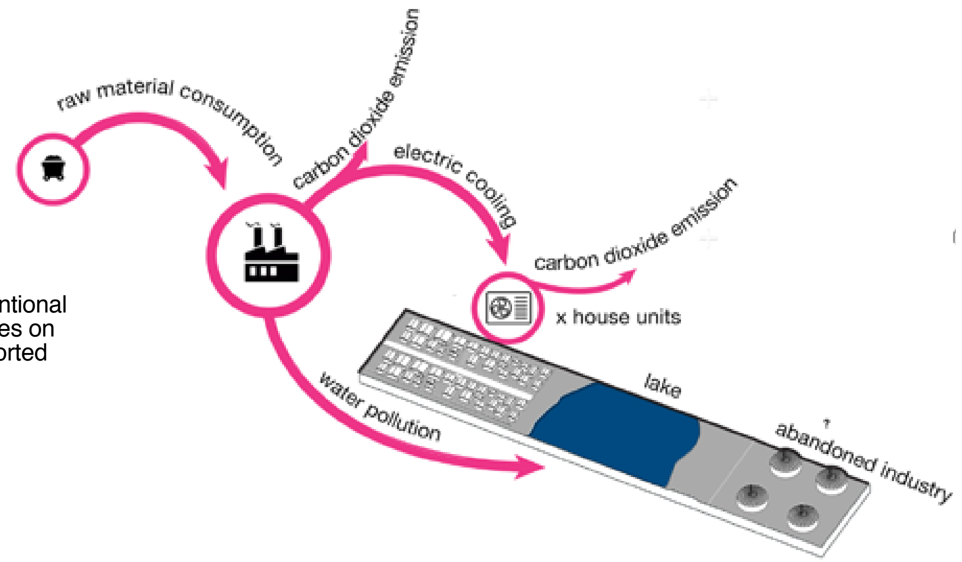


Figure 0.02 Conventional cooling system relies on unsustainbale imported resources

ASSUMPTIONS

To achieve the goals of this creative project, the following assumptions are made:

1. The tank farm is abandoned.
2. The deconstructed tanks can be refabricated to support green infrastructure and various recreation programs.
3. The brownfield has been remediated and is therefore suitable for housing development.
4. The abandoned rail line is suitable for ice transportation and community public transportation.
5. The slag can be unitized for thermal insulation.

DELIMITATIONS

Because of limited time and resources, the following limitations are made.

1. This project does not include funding, cost estimates, and construction.
2. This project does not cover future maintenance design.
3. This project does not calculate energy degradation.
4. This project does not follow the existing zoning guildlines.
5. This project does not include detail of planting design aspects.

METHODS

The Methodologies of this project include: literature review, on-site observation, case study, data collection and design.

Literature review

Literature review is the first part of the research methodology. It includes two points of relevant literatures and documentation. For the relevant literatures, it addresses design principles,and the methods and technologies that are relevant to the problem statement, such as brownfield redevelopment, snow cooling systems and etc.The relevant documentation also addresses site history and site data.

Case study

The case studies cover some of questions from the problem statement. The selected case studies presented realistic situations that helped the designer to create a design solution for the creative project.

On-site observation

On-site observation included two parts. The first part of on-site observation focused on experiencing and recording the site, including the major elements on the site, green space, open space, circulation, etc. The second part focused on the surrounding situation of the site, including the major elements around the site, community, traffic situation and public transportation. The on-site observation helped the designer gather more human scale data for the project.

Report of data collected

Upon conclusion of the methodologies, A report was generated of data that was collected and all other useful information during the research period. This data was then used in programming of the site and re-shaping the design problem statement.

LITERATURE REVIEW

The literature review covered the seasonal ice cooling system and brownfield redevelopment. Also, considering this project reclaims natural ice as a cooling material, ice properties and ice storage were studied.

Seasonal ice cooling system

The seasonal ice cooling system uses ice or snow for cooling distribution. Different from a conventional ice cooling system, it is a seasonal strategy of cooling storage and distribution.

Ice properties

Ice is the soild form of water. The heat capacity of ice is 4.18 kJ/kg (1.2 Wh/kg); the latent energy of melting is 334 kJ/kg (92.8 Wh/kg), and the ice melting point at 0°C. "This storage capacity means that it requires 100 kWh to transform 1000 kg of ice at 0°C to water at 5 °C"(Snow,1). The following digrams show that comparing same amount of ice and water, the ice has larger cooling energy storage capacity than water.

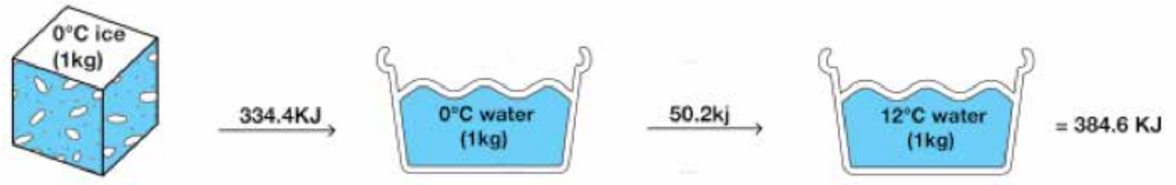


Figure1.01 ice cooing system operates between 0 and 12°C

Figure 1.02 chiller cooing system operates between 7 and 12°C

The capacity of an ice cooling thermal system (CTES) is 18 times as high as that of water CTES (Kurodia, 1993). Therefore ice is an excellent material for cold storage.

Considering these advantages of ice, some energy efficiency chillers use ice as a cooling storage material. The operating principle is one of producing ice during off-peak periods and using ice for cooling at later time. Compared with seasonal natural ice cooling systems produced ice has more energy exchange capability.

Seasonal ice storage

Seasonal ice storage is an ancient technology that was common until the beginning of the 20th century when chillers were introduced. The oldest snow/ice storage reference found is an ancient Chinese book of poetry mentioned ice as being stored underground (Morofsky, 1985).

Ice storage design principles

All ice storage method means is that ice is stored in a thermally insulated mass for later use. Currently, there are three types of ice and snow storage systems: insulated building, insulated pit and underground storage. Based on local air temperature, rainfall, ground water level and local nature insulation material, the designer can pick the suitable storage type for a project.

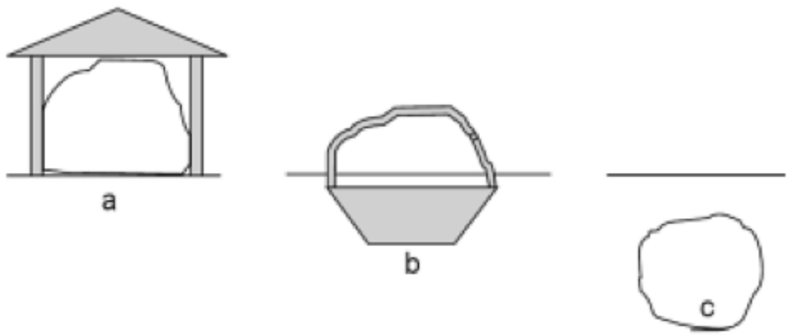


Figure 1.03 Outline of different ice and snow storage (a) in a building, (b) in a pit, and (c) underground (Cabeza, 189).

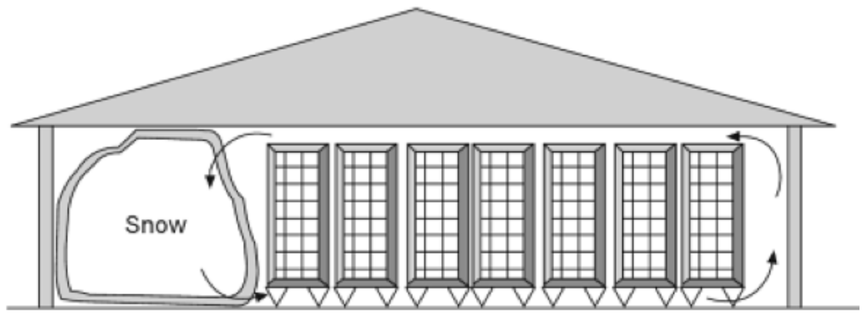


Figure1.04 Section through a building, showing how snow and the cooled stuff are stored in the same space (Cabeza, 190).

Storage in a building

The process begins by loading snow or ice in an ice room and placing the coolth storage object in the same building. The snow and ice maintain a low temperature and high relative humidity in the storage room. Usually, circulated air is considered as coolth carrier for the system.

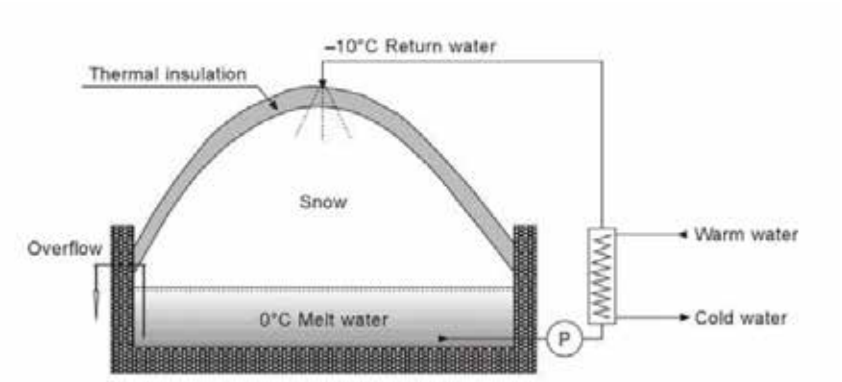


Figure 1.05 Outline of snow storage in a thermal pit (Cabeza, 191).

Storage in a pit

The concept is to store ice or snow partly below the ground in a watertight pit during the winter. Once the pit is filled with ice, it will be covered by thermal insulation.

Stored ice and snow naturally melt by heat leakage. Then, the 0°C melted water forms a puddle at bottom of the pit. The 0°C water is then pumped to the house as coolth carrier. The return water will spread on top of the snow pit and can produce more 0°C water for cooling reception.

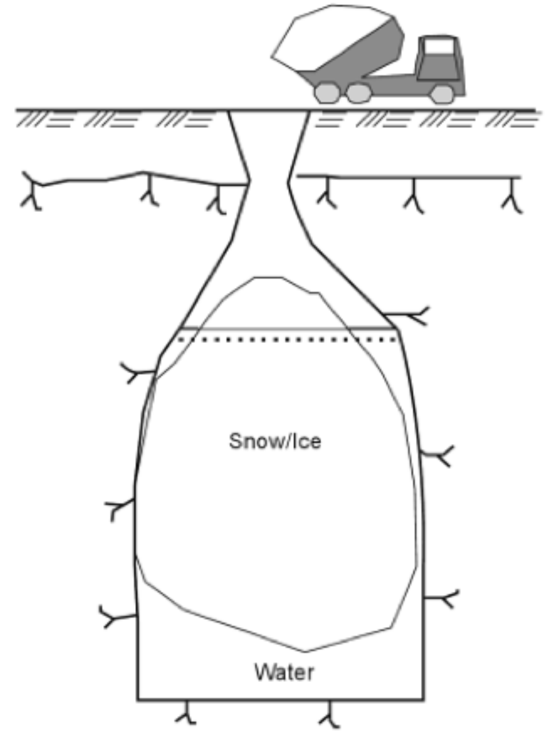


Figure 1.06 Outline of rock cavern snow storage (Cabeza, 193).

Underground storage

Underground storage uses a natural underground cavern as storage space. The ground itself serves as the insulation material that reduces heat leakage. Some research proposes that building an underground ice and snow storage in the center of a city will reduce transport costs of snow. Also, the ice resource is stored close to cooling demands.

Evaluation of the three types of storage systems

Storage in a building: If this building is located near demands ,the ice storage combines with the building to reduce coolth transfer distance. It improves energy efficiency but there is a high cost of land in densely populated areas.Also, the building cost can be higher.

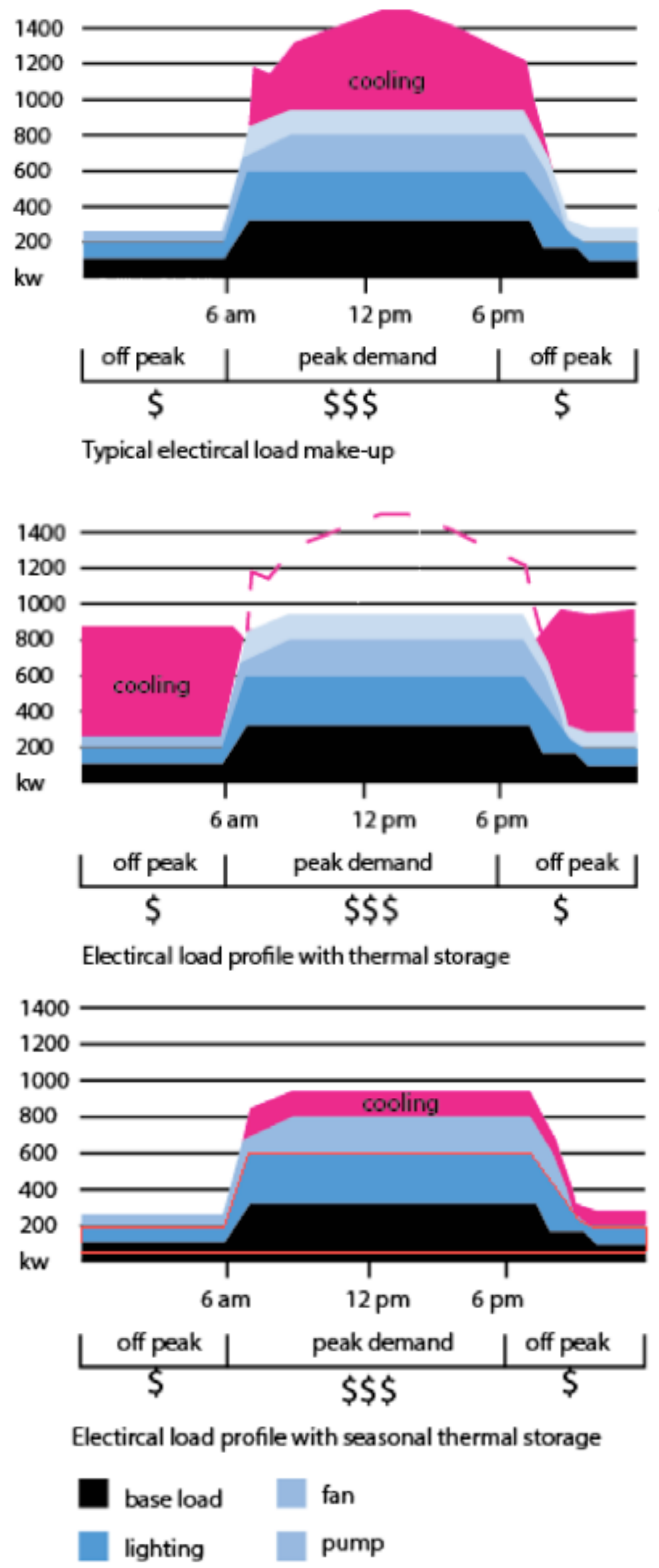
Storage in a pit: A pit usually is an half open storage so that ice resources can load effectively in the pit. Compared to the ice storage building, storage in a pit requires a smaller budget for construction. However pit storage is not suitable for a city that has, on average, a very high temperature.

Underground storage: This methods utilize nature's underground cavens as storage space that does not need insulation material. Overall, it requires less construction fee. But it is not easy to find a suitable existing cave for new development.

Advantage of seasonal ice cooling system

1. Natural ice is a renewable and "free" resource. Strategies that using natural ice can reduce emissions of greenhouse gases and the dependency on fossil fuels.
2. Using natural ice has historic value for places already known for ice-harvesting.
3. "The ice melt runoff is smoothened out over a longer period and it is possible to control the contaminated melt water" Snow, 1).
4. Natural ice making and harvesting can also support different recreational and education events.
5. Strategies that use centralized cooling system can improve energy efficiency and reliability. Also, they can reduce noise pollution from local compressors.

Figure 1.07 Economic impact comparison between typical electrical cooing, electrical thermal storage cooling and seasonal thermal storage cooling.



The history of nature ice harvesting

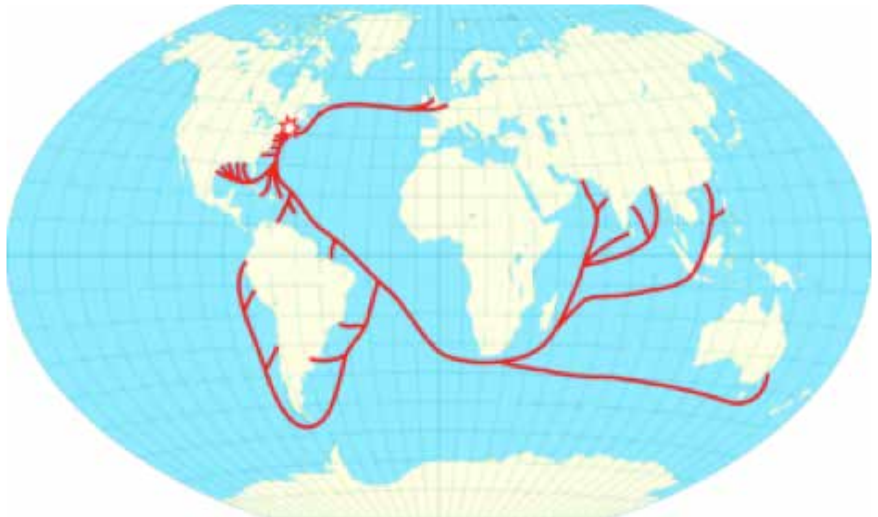


Figure 1.08 The growth of the New England ice trade by 1856; star indicates New England (ice trade)

Humans have a very long history of ice harvesting and storage. Natural ice harvesting was widely commercialized as an ice trade industry globally during the 19th and early 20th. At that time, natural ice was considered the first important product of a year being harvested in January and March.

> “ The ice trade started with the harvesting of ice from ponds and rivers during the winter, to be stored for the summer months ahead. Water freezes in this way once it falls to a temperature of 40 °F (5 °C) and the surrounding air temperature drops to 32 °F (0 °C).[10] Ice needed to be at least 18 inches (0.46 m) thick to be harvested, as it needed to support the weight of the workers and horses and be suitable for cutting into large blocks” (Weightman,188).

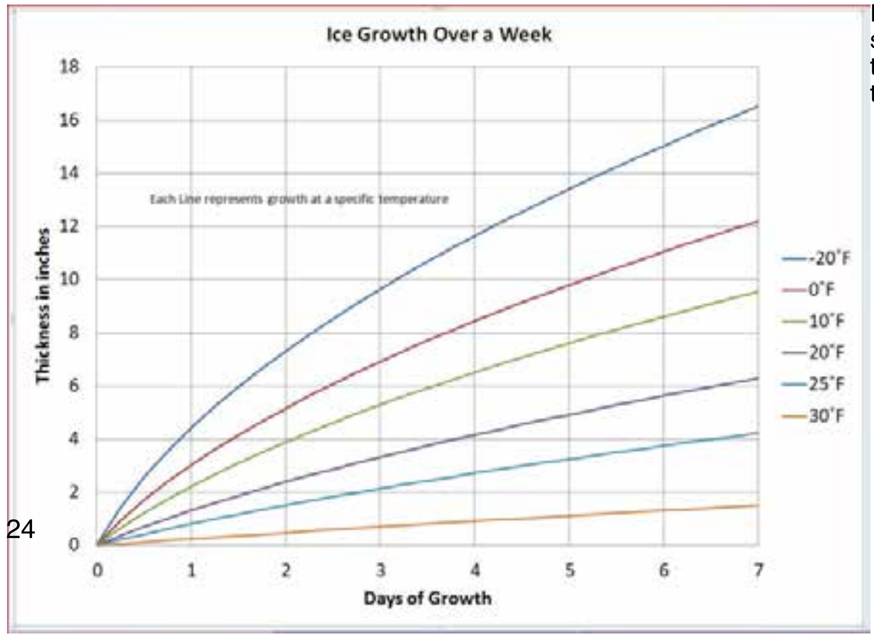


Figure 1.09 The diagram shows the relationship between temperature change and ice thickness (Lake Ice,Web).

Figure 1.10 industry. Ice Harvesting, Plowing Ice. NYSA_A3045_830 (ice,2015).

Ice harvesting and trade used to be a global industry. The industry generally collapsed because modern refrigerators became common in people’s daily life. “ The use of natural ice on a small scale lingered on in more remote areas for some years, and ice continued to be occasionally harvested for carving at artistic competitions and festivals, but by the end of the 20th century there were very few physical reminders of the trade” (Weightman, 191).

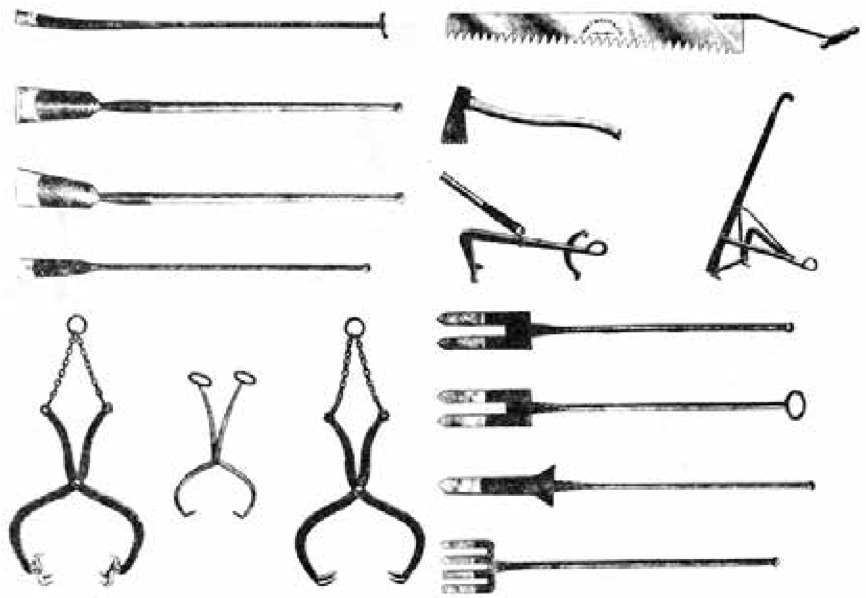


Figure 1.11 Selection of late 19th century specialist ice tools; clockwise from top left, chisels; ice saw, ice adze, grapples; bars; tongs (Wikipedia, 2015).

Brownfield redevelopment

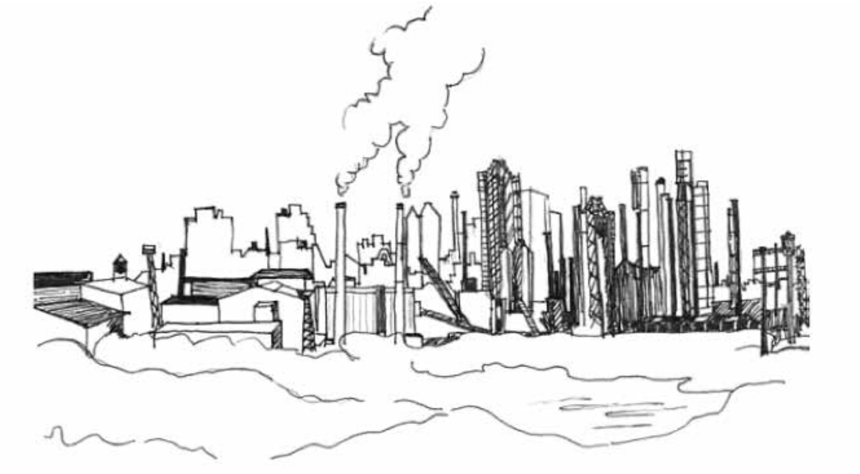


Figure 1.12 abandoned factories within active industry, often set apart from other uses, like the rolling greenfields in the foreground (illustration by Luisa Oliveira).

“A brownfield is an abandoned, idled, or underused industrial or commercial facility in which redevelopment is burdened by real or potential environmental contamination.” Brownfield brownfield reclamation and subsequent redevelopment create benefits in many ways for local communities, such as community’s park, retail center and local habitat restoration places.

To develop a seasonal ice cooling system for a community requires a large space. Also, considering maximizing benefits for local community and wild life, site condition as a brownfield is one of the site selection criteria.

Brownfield redevelopment benefits

“By taking full advantage of existing infrastructure, cleaning up contamination, and leaving green-fields untouched in their virgin states, brownfields take center stage in a sustainable planning strategy of thwarting sprawl, preserving open space, reducing greenhouse-gas emissions, and reinvesting in urbanized areas and their communities” (Hollander, 2010).

The benefits of Brownfield redevelopment include:

1.Brownfield redevelopment is good for the property owner.

2.For cities and towns, brownfield redevelopment is beneficial to economic, ecological and social environment.

Brownfield redevelopment challenges and technologies

The challenges of brownfield redevelopment include:

Reusing abandoned structures, cleaning up contamination and restoring the local ecological systems.

According to recently research, cleaning up contamination on a brownfield mainly includes three different strategies: capping, removing, and remediation.

Capping:

“Capping in place involves creating and maintaining a hard surface, usually concrete or asphalt, over contamination. The result is a high strength; low permeability cover that reduces surface water infiltration and stabilizes contaminated soils. As a result, the cap prevents contact with the contaminated soil and contaminant mobility is limited protecting ground water”(Engineering controls on brownfields information guide, 2010).

Capping is a quick way to solve the issue of contaminated soil on the site. For this strategy, the contaminated soil is usually deemed as a useless resource.

Removing:

Removing the contaminated soil and water out of the site is the quickest way to clean the contaminant. But the strategy is usually suitable for a small-scale development. Because the following reasons:

1.The costs of this removal fee is very high.

2.The transportation of contaminants adds pressure to local transportation systems.

3.The removed contaminted soil need to be cleaned that add on to the total cost.

Remediation:

Remediation technologies are environmental friendly solutions to solve the problems associsted with contaminant. According to the book of principles of brownfield regeneration (Hollander,2010). the remediation technologies include: established treatment technologies, innovative alternative-treatment technologies and emerging alternative-treatment technologies

Figure 1.13 The above technologies list is summarized from the book of Principles of brownfield regeneration (Hollander,2010).

Established treatment technologies	Innovative alternative-treatment technologies	Emerging alternative-treatment technologies
Air sparing	Bioremediation	Land farming
Bioventing	Natural attenuation	Phytoremediation
Encapsulation	Soil washing	
Excavation	Thermal desorption	
Incineration		
Permeable reactive barrier		
Pump and treat		
Soil vapor extraction		

Design principles for stormwater management on brownfield

Stormwater management is a big challenge in a brownfield redevelopment project. Because of the on-site contaminated soil and water, the contaminated runoff could pose a threat to the surroundings. According to the EPA's research, green infrastructure and low impact development are effective methods to manage stormwater on a brownfield site.

"Green infrastructure seeks to reduce or divert stormwater from the sewer system and direct it to areas where it can be infiltrated, reused or evapotranspiration" (Design principles for stormwater management, 2008). Low impact development techniques manage stormwater close to the source in a way that replicates the pre-development management of water on a site (Hawkins et al., 2012).

"General Principles for Using Green Infrastructure on a brownfield site:

1.Differentiate between groups of contaminants as a way to better minimize risks.

2.Keep non-contaminated stormwater separate from contaminated soils and water to prevent leaching and spreading of contaminants.

3.Prevent soil erosion using vegetation, such as existing trees, and structural practices like swales or sediment basins.

4.Include measures that minimize runoff on all new development within and adjacent to a brownfield. These measures include green roofs, green walls, large trees, and rainwater cisterns" (Design principles for stormwater management, 2008).

For low impact development on brownfiled, analysis of site runoff within the water shed is a basic point. "In particular, projects in groundwater recharge areas should avoid low impact development practices that promote infiltration, and use techniques that directly discharge treated stormwater instead" (Design principles for stormwater management, 2008).

To sum up, according to Hollander's considerations in a brownfield redevelopment project, the three most important elements on a brownfield are soils, site drainage, and vegetation. From the perspective of landscape architecture, a site development is not only considered a sustainable technology solution but also a sustainable cultural solution. So, site history and on-site abandoned structures are also considered as important elements to drive site development.

Case studies

This creative project chose to include case studies from the past ten years to show the values and the opportunities of seasonal ice cooling systems and brownfield adapt reuse. They are the Sundsvall Hospital snow cooling plant, Westminster Pier Park and Gas Works Park.

Sundsvall hospital snow cooling plant

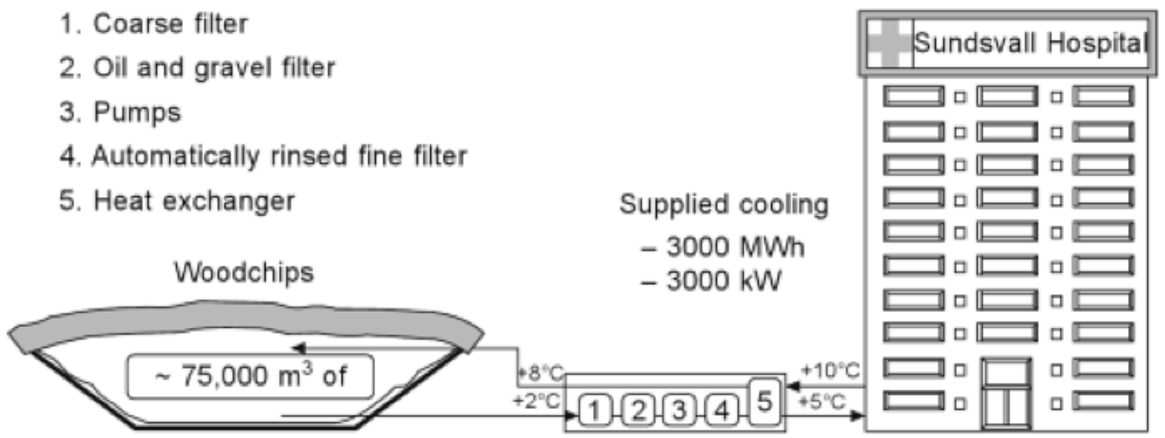


Figure 1.14 Outline of the snow storage system for cooling of the regional hospital in Sundsvall, Sweden (Cabeza, 193).

Brief description:

The Sundsvall Hospital snow cooling plant is located at Sundsvall, Sweden. The design concept of the plant is storing city snow dump in a shallow sloping pit during winter, using the snow dump to generate cooling for the hospital. Currently, the plant covers more than 90% of the cooling consumption of the hospital.

Figure 1.15 Photo of sundsvall hospital 's snow pit and sawdust (Stored Snow for Summer Cooling).

Figure 1.16 aerial photo of sundsvall hospital snow cooling plant (Google Earth)

Figure 1.17 Photo of sundsvall hospital (sjukhuset).

Program of Sundsvall hospital cooling system:

The cooling system mainly includes three parts: the snow storage, a pumping station and a heat exchanger.

The snow storage: The snow storage includes a 140 m by 60 m square shape snow pit. “The initial volume of the snow pile was set to 30000 m3. The density of the compacted piled snow was assumed 650 kg/m3 and does not change during melt (Snow, 6).”

Pumping station: The pumping station includes two water pumps that pump the 0°C ice melt further towards the hospital building.

Heat exchanger: The water coming from the snow storage holds a temperature of approx. 2°C, which cools down the water come back from the hospoital from12°C to 7°C.

Significance:

This case study shows the snow cooling plant has significant environmental value and economic value.

Environmental impact of Sundsvall hospital snow cooling plant

The Sundsvall hospital snow cooling plant has an environmental impact, the Kjell Skogsberg research paper shows four categories of environmental impact through compare snow cooling and chillers. There are climate change, acidification, nitrification and formation of photochemical ozone.

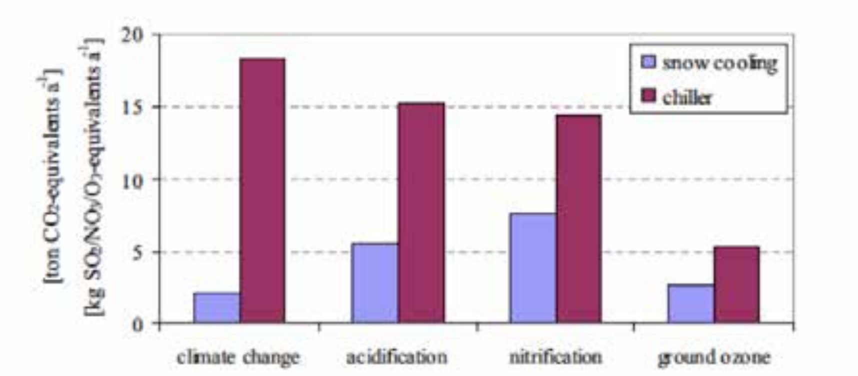


Figure 1.18 Environmental impact from “environmentally optimised” snow cooling and chillers systems concerning climate change, acidification, nitrification and formation of photochemical ozone. Units are [ton CO2 equivalents a-1] for climate change and [kg SO2/NO3/O3 equivalents a-1] for the others (Skogsberg, 63).

According to the diagram above, traditional chillers have more environmental impact than seasonal ice cooling system.

Economic impact of Sundsvall hospital snow cooling plant

“The energy requirement to cool the hospital used to be 900 MWh per year but snow cooling requires only 65 MWh for pumps”(Snow cooling). Also, the hospital could make money from snow dump service. the above advantages shows the snow cooling plant has significane economic value.

Potential of the seasonal cooling system

The Sundsvall hospital snow cooling plant is a successful example of a seasonal cooling system. By applying the seasonal cooling strategy, it can lower emissions of greenhouse gasses and reduce dependency on fossil fuels, all with minimal environmental impact. Also, faster phase-out of ozone-depleting HCFC gasses, improved energy efficiency and reliability from larger centralized maintenance systems are additional potential benefits

The seasonal cooling system has lot of advantages that could be a basic green infrastructure strategy for future cities or communities. Currently, the seasonal cooling system is not as well known as it should be. As a landscape architecture student, one way to spread the idea of seasonal cooling system is to connect the seasonal cooling system with some well known sustainable design strategies in the landscape architecture field, such as stormwater management strategies and environmental education strategies. Therefore, people could see the dynamic potential of the seasonal cooling system.

Figure 1.19 The future site of Westminster Pier Park. Taken July 2010 by Dennis S. Hurd

Figure 1.20 The new westminster Pier Park (westminster pier park, web).

Westminster pier park: New Westminster, Canada

This case study was selected because of its similarities to the site selection criteria. It is located in an important ecological zone and near a historical waterfront area.

The park is located on the Fraser River, which is one of the world's most important salmon spawning rivers, and the site also connects the historic downtown to the river, (Westminster Pier Park). The main access to the park is along Front Street. As well as the New Westminster sky train station, the Columbia sky train and Pattullo Bridge surround the park.

Major space sizes: "Site 3.6 hectare (9 acre site, with 600 meter 1969 feet) of water front" (McManus).

The 600-meter liner boardwalk is the largest space, which connects all the programs on the site. The festival lawn is the second large space on the site, which can support 2000 people's activities.

Date competed: 2012
Location and context, connections:
1 Sixth St, New Westminster, BC V3M 6Z6, Canada

Client: City of New Westminster
Landscape architecture firm: PWL partnership

Budget or final cost:
The project cost about $ 33million($8.0 million for property)

Figure 1.21 westminster pier park site plan (montecristomagazine)

Brief description:

The Westminster Pier Park, a former industrial dock with contaminated soil and abandoned infrastructures, was a brownfield site that separated the historical downtown from the Fraser River. Following redevelopment June 16th, 2012, it is now a 2.5km liner urban waterfront park that includes "a 600 meter water front boardwalk, festival lawn, concession, elevated viewpoints, grass, trees, gardens, benches, accessible picnic tables, two sand volleyball courts, a basketball court, public art and two preschool aged playgrounds"(Westminster Pier Park). The park connects the surrounding communities to the river that enrich the waterfront city's culture. It provides a place for people to gather, recreate and learn about benefits not only for now but also for future.

Design concept:

Based on the site context, the designer divided the site into three parts: a city playroom, a city living room, and a front porch. Each part connects with the city circulation system and accommodates different programs, such as a fishing pier, picnic area and bike path. A sustainable development approach using recycled materials and reusing the old constructions was taken on the site.

Figure 1.22 westminster pier park site photo (PWL)

Significance:

The park provides a new intertidal habitat for fish and wildlife. Also, the designer chose native plants for the site, which is good for local wildlife. The dynamic design language shows the feeling of a modern city. It is a new destination for downtown.

Figure 1.23 The mothballed gasworks, 1966 (Jmabel)

Figure 1.24The park seen in 2011 (photo by Liesl Matthies)

Date competed: 1971-1976

Location, context and connections:
2101 N Northlake Way, Seattle, WA 98103

Size and major space size:
8.3 ha projecting 122m2 into lake union with 579m2 (Thaïsa Way).

Client: Seattle parks department and city of Seattle

Landscape architects:
Richard Haag Associates, Seattle, WA, USA

Gas Works Park: Seattle, WA

The park was called Elliott Bay Park (1975-1976).The site is a waterfront park "located on north shore of the Lake Union at the south end of the Wallingford neighborhood" (Gas Works Park). The constructions along the edge of Lake Union are shipyards except for the Gas Works Park. The major elements include an artificial kite hill, six gas storage tanks and some old large equipments.

Brief description:

The site was owned by a plant and was used to manufacture gas from coal . The plant provded gas for streetlights ,heating and cooking in Seattle from 1906 to 1956. After the plant shut down, the city acquired the site for a park in 1962. Richard Haag, who is the designer, thought the site represented the culture of Seattle. Therefore, he asks to protect most of significant constructions on the site.

The soil and groundwater of the site was contaminated during operation as the gas plant. So, US Environmental Protection Agency and Washington State Department of Ecology decided to cap the soil and contamination as a large open space.

Also, a bio-phytoremediation approach was taken to remediate contamination on the site. That was seen as a unique way to solve brownfield issues at the middle of the 20 century (Gas Works Park).

Design concept:

The design concepts come from three intentions:

One was established by John C. Olmsted ‘s suggestion “ the point of land …. Should be secured as a local park, because of its advantages for commanding views over the lake and for boating, and for a playground” (Olmsted 1903: 47).

The second intention of the designer ‘s life story that “designer engagement with scientists in his experimentations with landscape remediation and reclamation opened new areas of inquiry into the adaptive reuse of post-industrial sites”(Gas Works Park).

The last intention is that all programs on the site should come from local people’s requirements.

The goals of the design included the following:

1.Process of persuasion: the first was to bring different groups into the process of “seeing the potential of re-thinking the possibilities of the site” (Gas Works Park).

2.The second was to use bioremediation to clean the contaminated soils and ground water.

3.The last was to use “landform as an art medium” (Gas Works Park).

Significance:

The significance of Gas Work Park includes two parts. One is providing a green space for the citizens. The second is for the project to have a very strong influence on landscape architecture. Contaminated soil and abandoned infrastructures were

challenges of this project. Especially at the middle of the 20th century, brownfield development was in its virgin stage of being incorporated out the landscape architecture design process.

In the Gas Works Park project, the designer kept the abandoned infrastructures as a landmark on the site, so they would help teach the history of the site to visitors. The thousands of cubic yards of rubble, when covered with fresh topsoil, became a hill known as the “Great Mound”.

Conclusion-to sum up the three case studies:

The significance of the Sundsvall Hospital snow cooling plant project shows that its seasonal cooling system has more economic benefits and ecology benefits than the conventional cooling system. Also, it also shows two disadvantages of the seasonal cooling system: 1) It needs a large space for cooling material storage, and 2) the filter had be disinfected because the project need sawdust as the insulation material. Also, from the perspective of landscape architecture, the system could have been designed in a more eco-friendly manner.

From the brownfield redevelopment case studies we can also know that contaminated soil and abandoned infrastructures are common issues for brownfield redevelopment project. The recent brownfield redevelopment projects have higher landscape performance benefits than the old ones. So that, based on new technologies, they have more efficient and sustainable ways to solve the problems associated with containment of soil and water.

Programing

The intend of the ice fuel project is to design the site redevelopment to test the feasibility of ideas informed by the literature review and the case studies. Therefore, elements and relationship were identified as part of the site programing for the ice fuel project.

The major program summarized was informed by the literature review and the case studies. The size and form of the programs were designed in response to site inventory, analysis and artistic vision input.

The overall project program included production programs, educational programs and entertainment programs.

Those programs are categorized into three critical components.

First, Ice harvesting and storage system. This system includes: Ice making place, ice storage, cooling generator and an ice transportation system.

Second, water harvest and purification system that supports on site water self-sufficiency. This water system includes:

Water resource: ice melt, rainwater, site and community runoff and on site grey water.

Water collector: green infrastructures, detention pound and bio-swales.

Water storage: cistern, pound, wetlands and tanks.

Water purification: constructed wetland, green roof, rain garden, bio-swales and nature wetlands.

Third, the ice cooling system provides cooling energy and water for the site amenities and local community.

To provide recreation, production and education benefits on the site and surrounding communities is one design concern. So, recreation, production and education programs were designed in the ice fuel project. Each shows how the ice cooling

system connects with other systems. They add benefits on the site and surrounding communities. Those programs include:

Production programs: community garden, fish pond, aquaponics, and plant nursery.

Recreation programs: sports filed, event space, splash plaza and recreation structures.

Education programs: the educational purposes are the most important design consideration for the ice fuel project. Most programs on the site have educational functions. The major education nodes include: ice making and harvesting places, a cooling system demonstration area, local ice history represent areas, water harvesting and purification demonstration areas and local industry history represent areas.

Site selection:

To implement the above programs, a site design is necessary for the creative project. The first part of the site design is to select the site location.

The location of the site shoud be selected among the flowing criteria:

1. The site has to near an inland lake that can produce ice during winter.
2. The site has a large space for building the infrastructure of a seasonal ice cooling system.
3. The site has to have a community or a city context that lets the project have more social value.

Sub -criteria:

1. The region should have ice harvesting history that maximizes the education value in the region.
2. reuse of a brownfield site that maximizes the ecological and economic value of the project.

SITE

+site selection
+site location
+regional history
+inventory + analysis

Site: BP oil tank farm, Hammond, IN

Site advantages:

The site's advantages include the following aspects: site location, types and regioanl history.

Site location:

The site is located in the northern town of Hammond, IN, at the intersection of Hammond, Whiting and East Chicago. The current function of the site is an oil tank farm. For the creative project, the site is proposed as an abandoned brownfield. To the north are the Lost Marsh Golf Course, Lake George and the city of Whiting. To the south are Highway 912 and another oil tank farm. To the west is a power sub-station. To the east is the BP oil tank farm and BP refinery.

Figure 2.01 aerial photo of the site 2015 (google earth)

N

0ft 5000ft

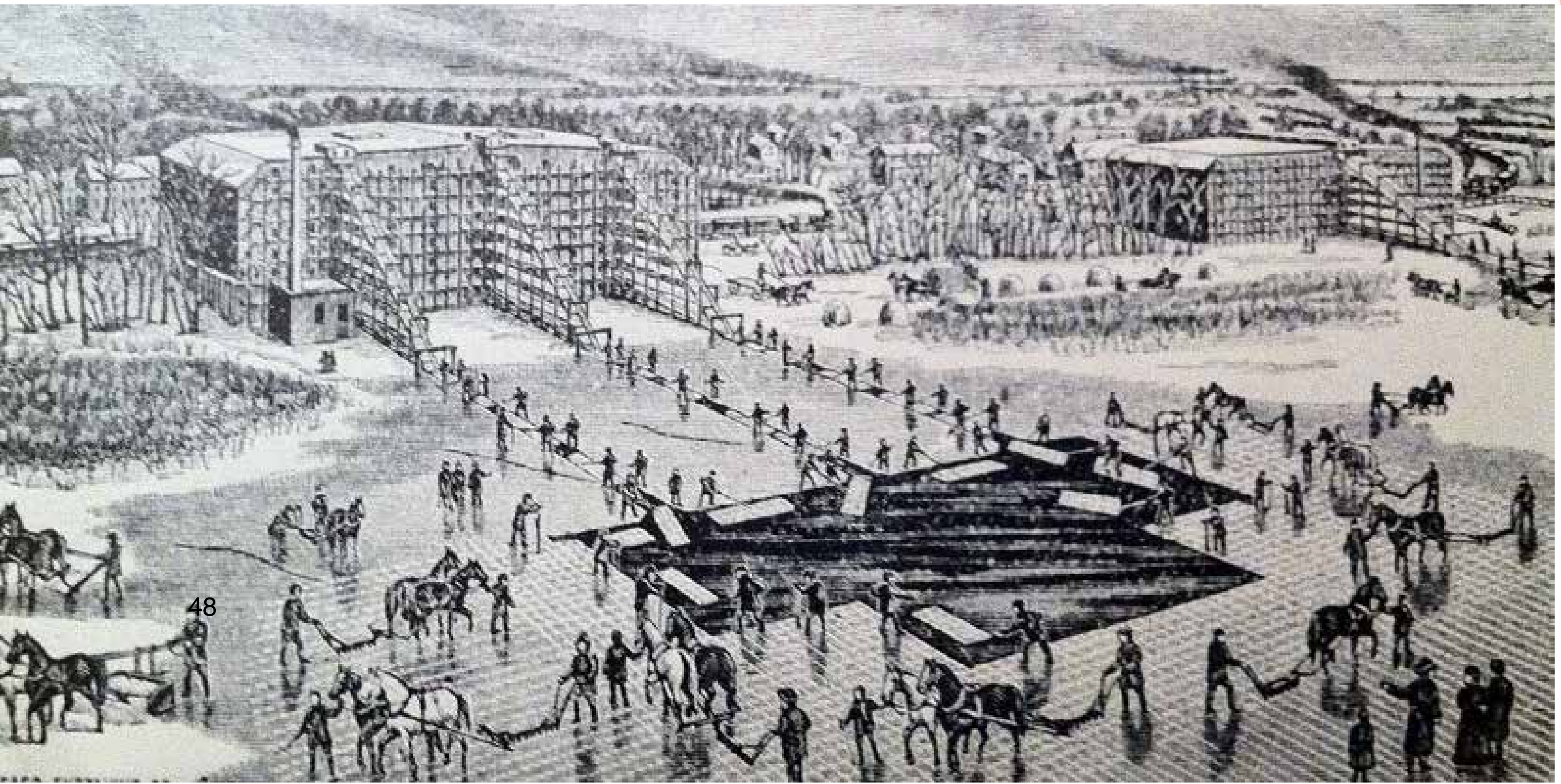
Regional history:

1. The ice harvesting industry and culture:

During the 19th centuries, ice served as the backbone of the regional economy. The ice provided refrigeration and cooling for the area, in addition to being an export commodity. The frozen renewable resource supported a local economy in an environmentally balanced manner during this period.

The ice harvesting industry disappeared from the region due to the fossil fuel industry that dominated the local economy and regional landscape.

Figure 2.02 Harvesting ice at Wolf Lake, Indiana, in 1889, showing the conveyor belts used to lift the product into the ice house (Lakeside Directory, web).



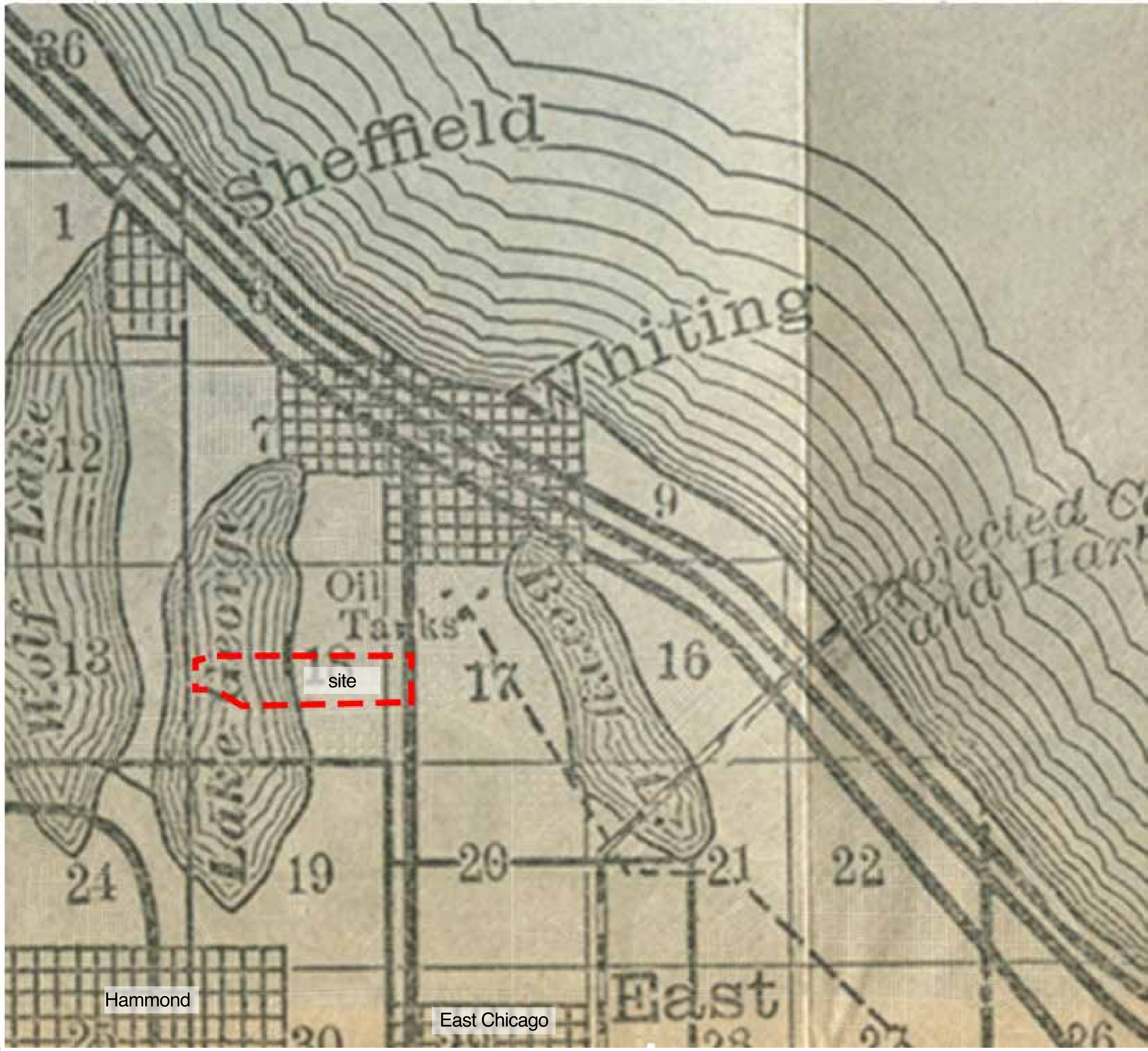


Figure 2.021 Aerial photo of the site 1890 (Porter County, web).
“Prior to development in the late 1800s, the region was dominated by extensive wetlands, sluggish rivers, and shallow lakes ”.

2. Fossil fuel industry and culture

> "Steel and slag production along the Chicago River began in the late 1830's. In the 1880's, the steel industry moved near the Calumet River in south Chicago. Slag was hauled to Indiana and used as lakeshore protection from erosion wherever the railroads followed the Lake Michigan beach. In 1903, a cement plant was built near Gary Station (later to become Gary, Ind.) to use the slag generated by the south Chicago steel industry for the manufacture of Portland cement. In 1906, the steel industry expanded into Indiana, and slag production quickly outpaced the demands of cement manufacturers. During 1945 to 1950, the Gary, Ind., blast furnaces produced 1,000,000 tons of slag annually. Slag disposal in swampy, low-lying land at the southern end of Lake Michigan became commonplace to accommodate the oversupply" (Bayless, 7).

The visual evidence of this shift is most recognizable in the landscape. especially in the Lake George region of Hammond (Fig 2.03). Historically, the area was dominated by freshwater marshes—a highly productive, diverse, and a resilient ecosystem. As the fossil fuel industry expanded, its waste byproducts (slag) continued to fill and destroy the freshwater marshes. Other industrial byproducts, such as wastewater and waste gas, caused further impacts that eroded the local landscape character and ecosystem health to an unrecognizable state. The on-going fossil fuel and traditional industries have not only left the environment in ruin, but the local economy is also suffering from outsourced industries and local disinvestment.

Figure 2.03 Photo of whting refinery (Distillation Unit Replacement Work Continues at BP Whiting Refinery).

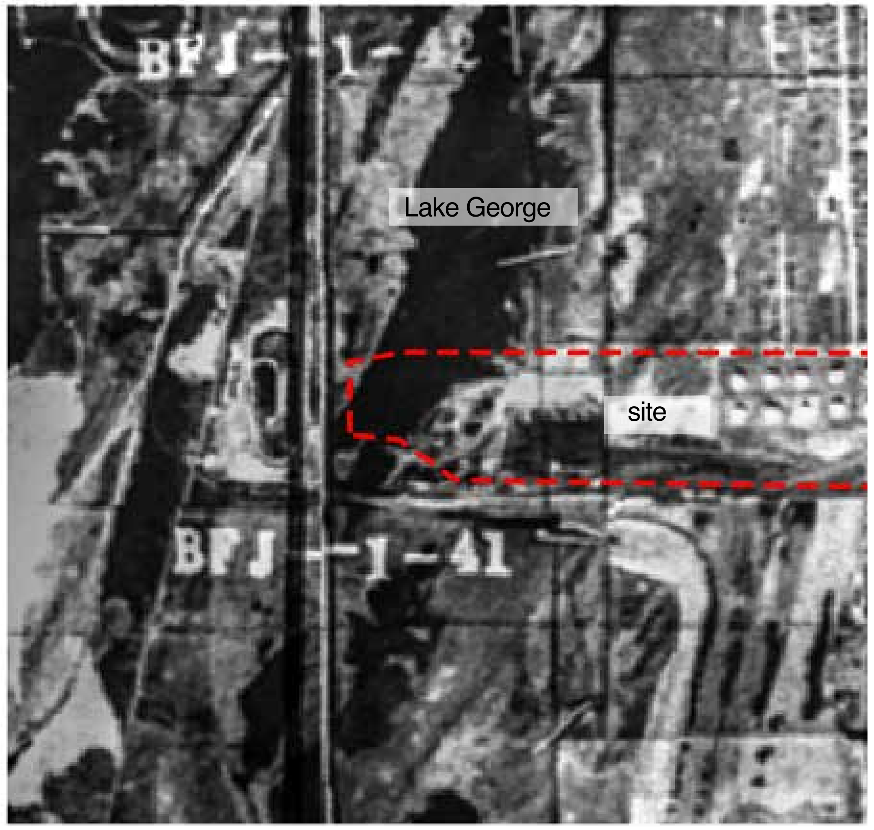


Figure 2.031 Aerial photo of the site 1939 (image collections online,web). Various steel-production, slags, fly ash and bottom ash from power plants, drums of oily sludge, and road-construction debris were filled in the lake.

Figure 2.04 Fire at Standard Oil in Whiting, IN August 28, 1955. photographer unknown

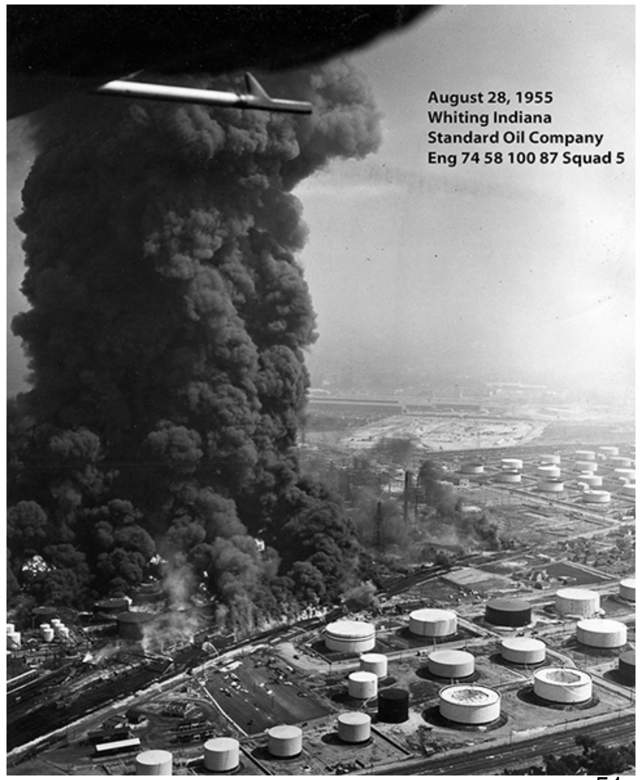


Figure 2.05 aerial photo of the site 2015 (google earth)

N

0ft 5000ft

The site inventory and analysis mainly focuses on three scales:

1. regional opportunities.
2. opportunities of site context.
3. opportunities of on-site elements.

Inventory+analysis:

1. regional opportunities

The regional analysis aims to find opportunities for site development of the project and also to map the potential land uses of future phase of the project.

Considering the region has a long and rich industrial history,the regional opportunities analysis are foucsed on the regional effect of industrialization, regional environment issues and regional education potential. It also included an analysis of regional industry land uses, vacancy of industry land and transportation issues , existing green space, hisotrcial land fill areas, underground oil tank situations and educational facilities.

Figure 2.06 Industrial land use

Industrial land use:
70% land is covered with heavy industry in the study area.

industrial land

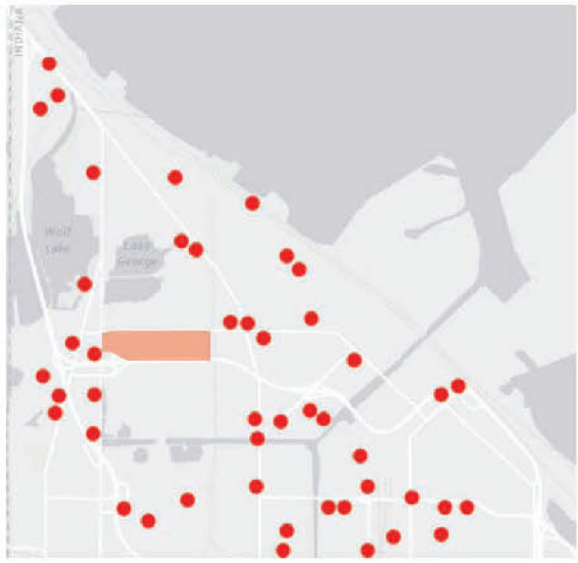
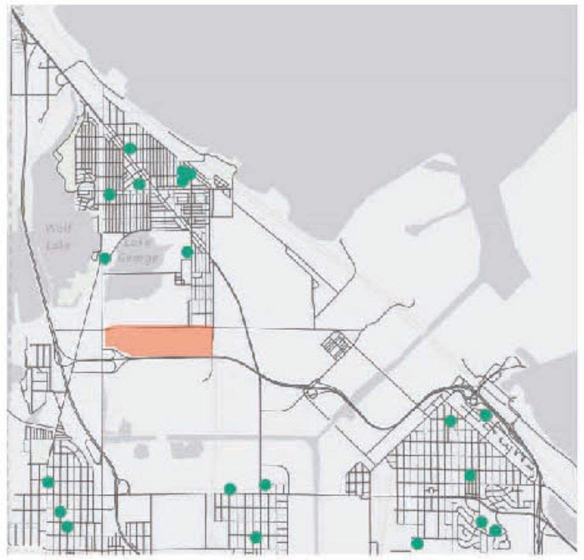


Figure 2.07 Abandoned Industries

Abandoned industries:
40% of industry site are abandoned in the study area.

Opportunities:
Adaptive reuse of the abandoned sites to provide sustainable benefits to surrounding communities.

abandoned industry



Education facilities:
The industry land separates the local schools and communities.

Opportunities:
the site provides opportunities for an educational hub for surrounding communities and schools.

education facility

Figure 2.08 Education facilities

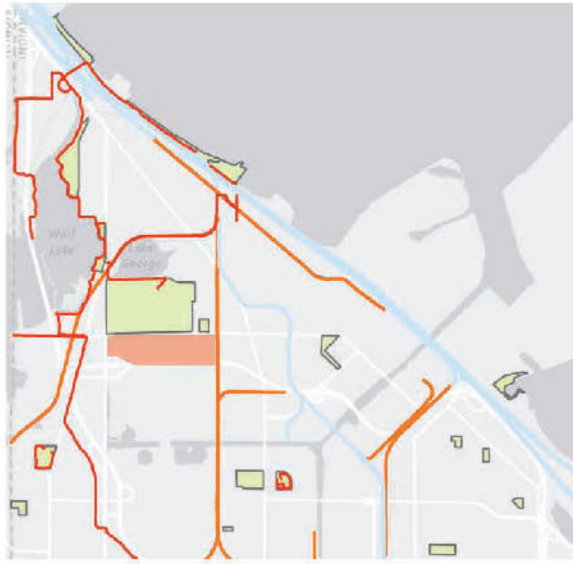


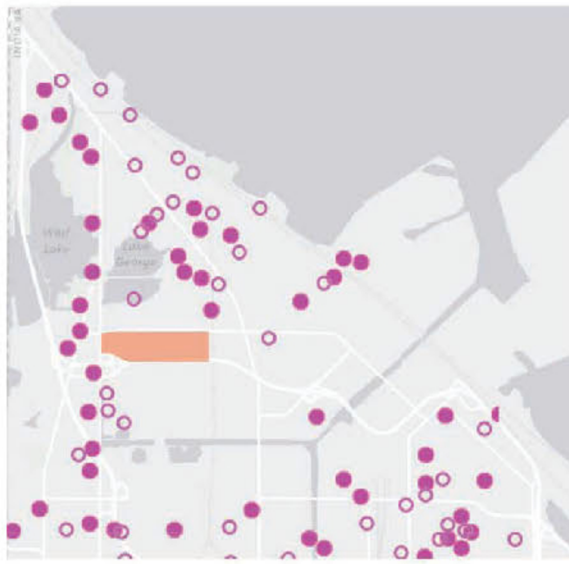
Figure 2.09 Green space & abandoned rail lines

Green space & abandoned rail lines:
The only large green space is a landfill golf course in the middle of the map.

Opportunities:
by making the abandoned rail system active, the abandoned rail lines will provide opportunities to connect the exisiting green spaces.

Figure 2.10 Historical landfill:

Historical landfill:
The slag landfill was a common problem for the region because it threatens the quality of groundwater.



Undergound tanks:
The leaking tanks threaten the quality of groundwater. Currently, at least 44 undergound tanks are leaking in the study area.

Figure 2.11 Undergound tanks

Inventory+analysis:

2. opportunities of site context.

The site context analysis focuses on finding site development opportunities from surrounding major elements. Those major elements include: Lake George, the abandoned rail line, the existing road system, lost Marsh Golf course and the lcoal community.

Those site development opportunities that can be identified from the major elements inlude:

1.ice production

2. ice resource transportaion system

3. ice cooling community

4. gateway for the site

5. amenities around the site

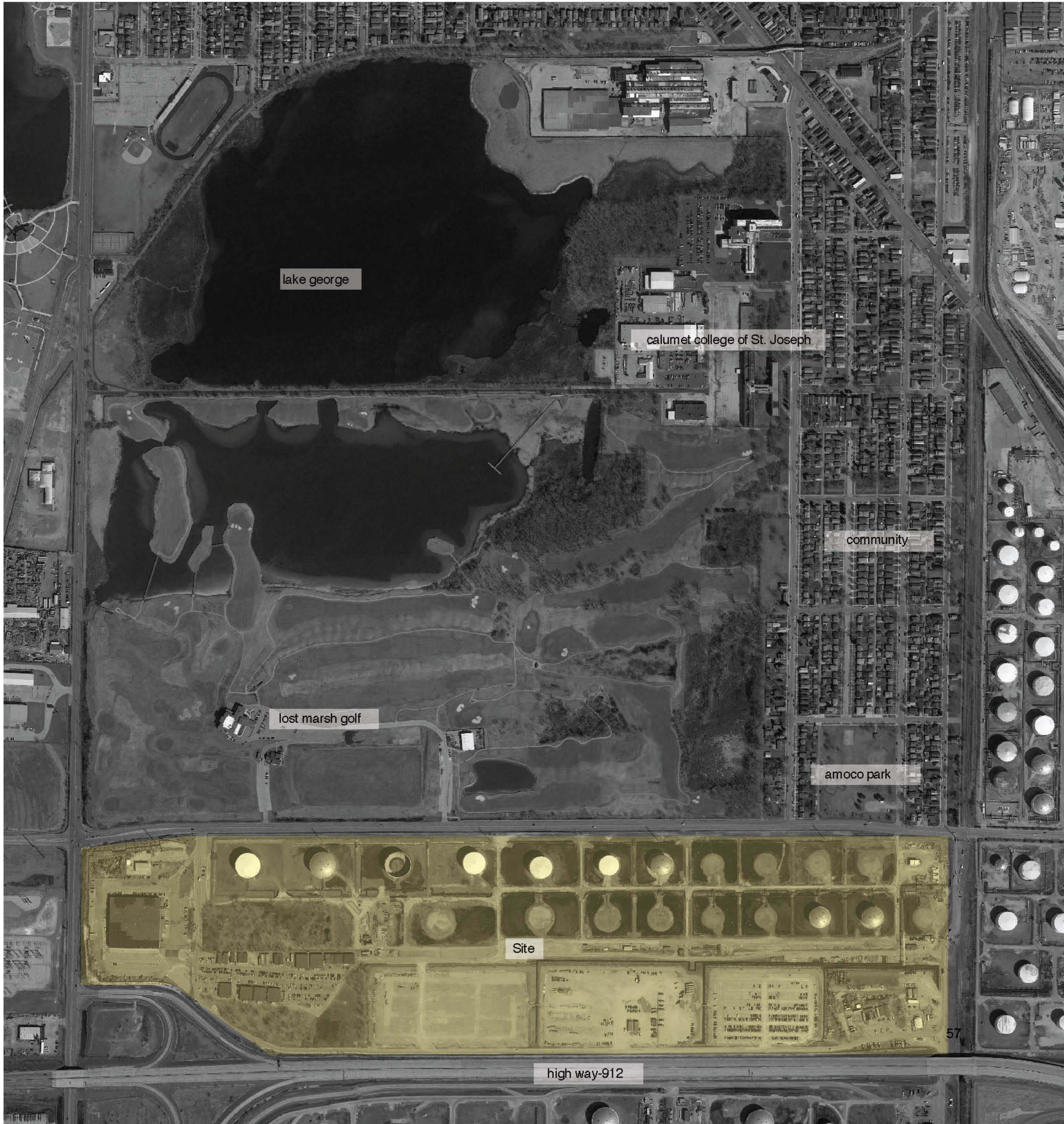
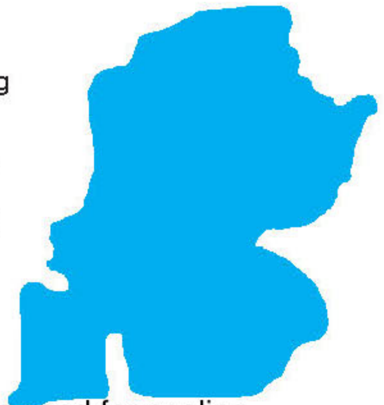


Figure 02.12 Site context map (google earth)

Inventory+analysis

site context- ice prodcution and cooling system



According to the following data, Lake George has a huge coolth energy capacity. Those energy can be used to satisfy a site cooling demand. It also could be used for cooling demand of the local community in the future.

Lake George:

Size: 104 acre

Depth:4 feet (average)

Water amount (gallons): 192,903,792

Ice production capacity (1.5 feet):

1,974,312 ton

~183,611,101 kwh

Inflows include:

Direct precipitation, watershed runoff and ground-water inflow.

Outflows include:

Surface evaporation, discharge at the lake outlet and groundwater outflow.

After the creative project established, the outflows of the water will be included ice harvesting. The inflows will be included purified water from the site.

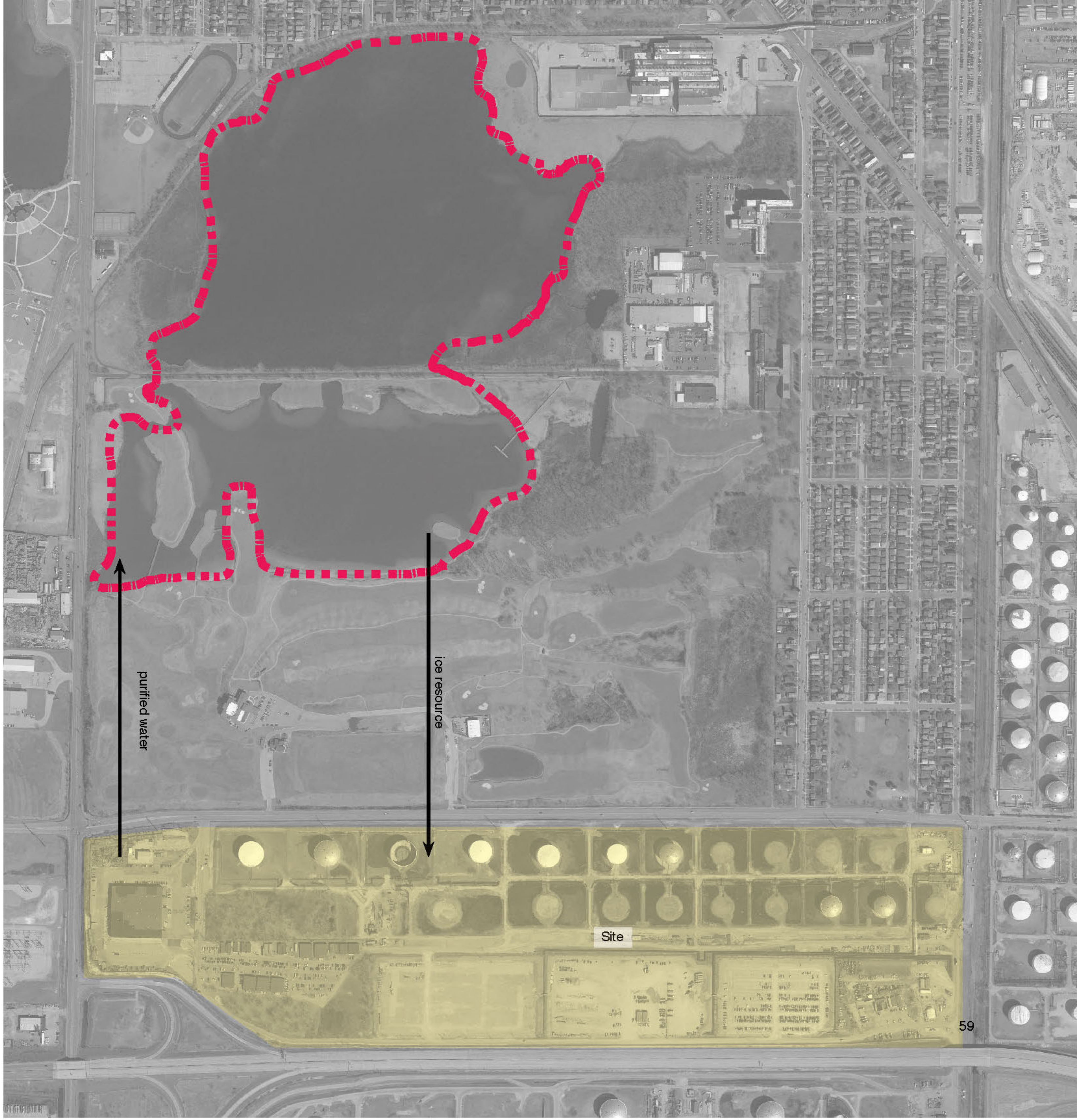


Figure 2.13 conceptual diagram of ice cooling system

Figure 02.14 Photo of the Lake George, March,07,2015

Site visit at Lake George on March,07,2015:
The historical ice harvesting event usually start at January each year. The photo shows the lake has more that 1feet snow cover on the lake surface. The snow cover as an insulation material reduces ice melting. Therefore, the lake still has amount of ice at March. Those ice could be used as coolth resource for the creative project.

Figure 02.16 depth of snow cover on Lake George.

Figure 02.16 depth of snow cover on Lake George.

Figure 02.15 Photo of the Lake George, March,07,2015

Figure 02.17 Ice survey on the Wolf Lake. March,07,2015
The result of ice survey shows the thinkness of ice is more than 1 feet, which means the lake has huge ice resource potential for the creative porject.

Figure 02.18 Ice cover on the Lake Michigan. March,07,2015
The ice is an irregularly shape that covered on the Lake Michigan.
The high point of the ice cover is about 6 feet to the lake surface. Those ice could be alternative resource for the creative project.

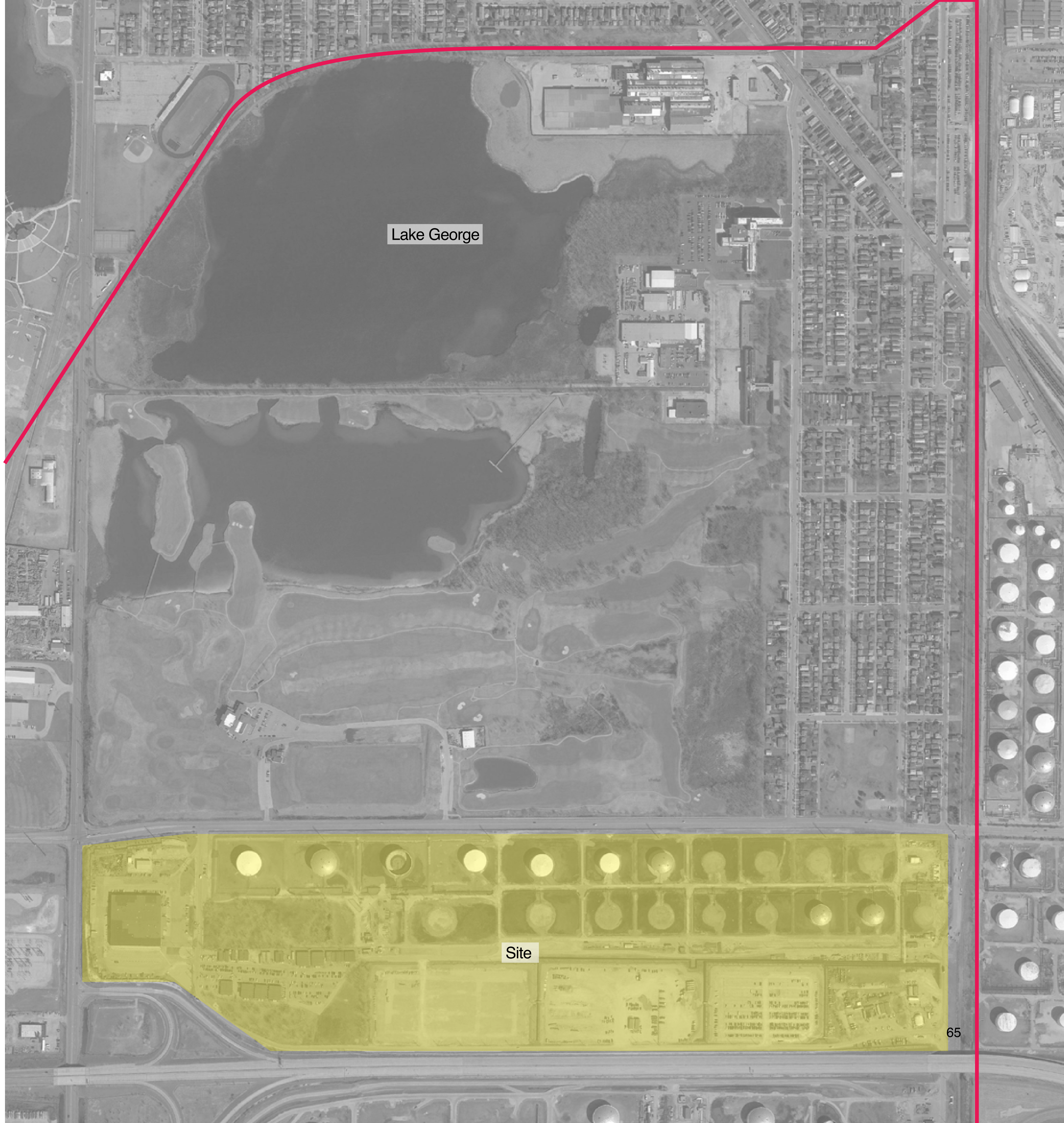
Inventory+analysis
ice resource transportation system

Abandoned rail line:

According to the regional data analysis, there has an abandoned rail line that connected the site, Lake George and surrounding communites.

The abandoned rail line can be reused for ice resource transportation from Lake George to the site in the winter.

After the ice harvesting season, the rail line can be used as a part of the local public transportation system to provide convenience to local communities.



Abandoned rail line

Figure 02.19 Site context of the abandoned rail line

Inventory+analysis
Ice cooling community

Community cooling consumption:

5204 Units

7,056,624 kwh=75,875 ton ice

The future phase of the creative project seeks to provide cooling energy to the communities. Therefore, the cooling consumption of the communities were calculated. The data of abandoned industry sites in the community are also highlighted. Those abandoned sites will be reused as community scale ice coolth generators In the future phase of the creative project . For the project, part of community runoff is considered as a water resource to support the demand of site development.

Abandoned industry
Figure 02.20 photo of the community.

Figure 02.21 Photo of the community park and the oil tank farm, March,07,2015

Figure 02.23 Photo of the community, March,07,2015

Figure 02.22 Slags on the community 's road. March,07,2015

Inventory+analysis
opportunities of surrounding amenities

Lost Marsh Golf Course

This area was originally a slag dumpsite called Bairstow landfill. The dumpsite has about 330 acres land and the depth of the slag dump varies 5 to 45 ft.

The dump site was abandoned in 1980. Because the slag is very heavy and hard, the local government could not afford to remove the slags. Rather, the government just covered it with sand. After years of metal-laden runoff, the pH level of the lake's north basin had risen to 12 and most wildlife cannot survive in the lake. Then, the government capped the slag with 130,000 cubic yards of bio solids and mixed it with 300,000 cubic yards of sand dredged from Lake George. In 2004, the government tacked the land to the Lost Marsh Golf Course.

Currently, the golf course is a tourist destination for local communities and tourists. The golf course provides an example of slag dump reuse for the region. Also, It benefits the creative project development by attracting people to this region.

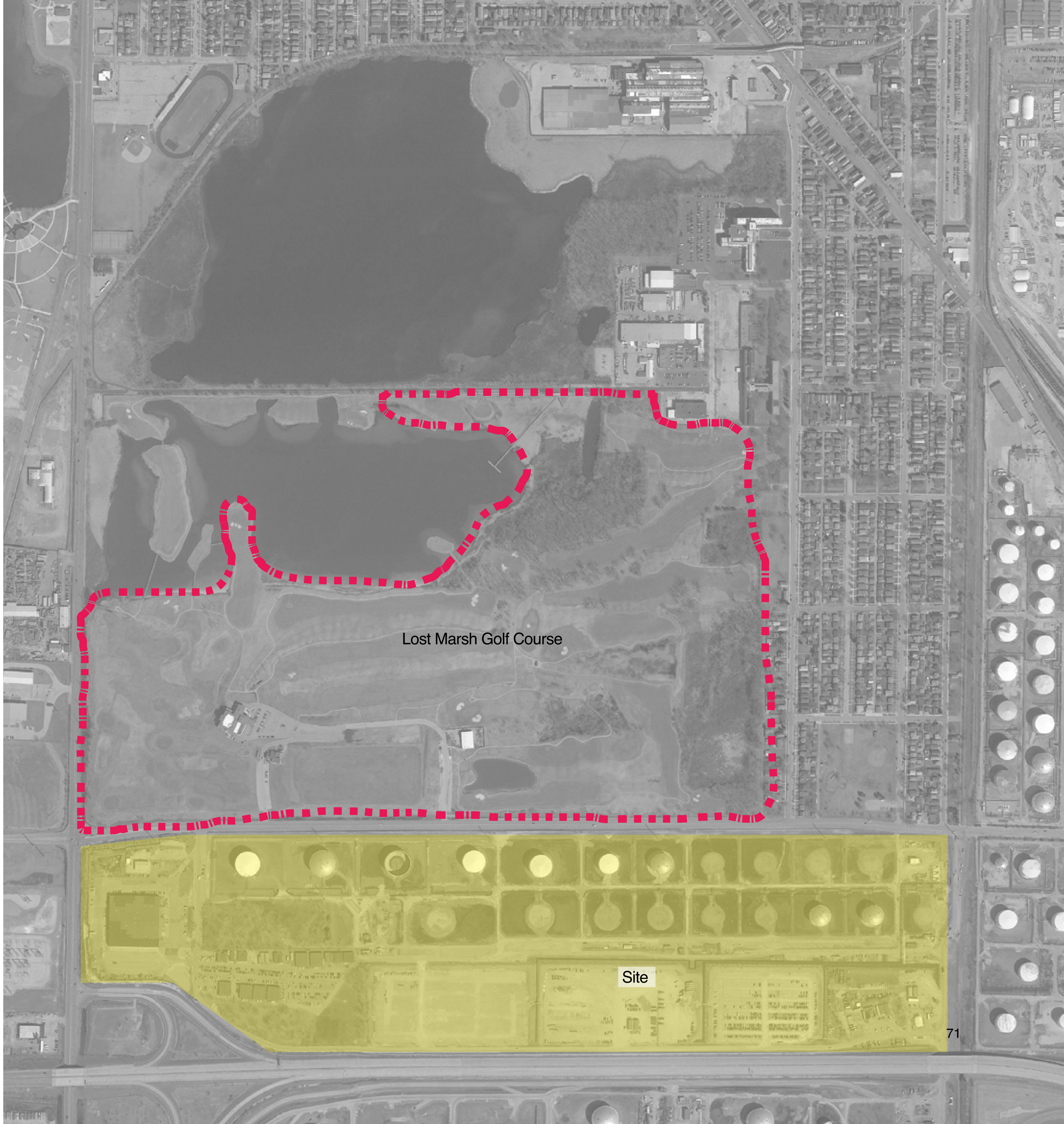


Figure 02.24 Site context of the Lost Marsh Golf Course

Figure 02.25 photo of the lost marsh, March,07,2015

The site visit photo shows the golf course is built on a landfill area. Also the golf course does not function during winter. Therefore, an opportunity of the creative project is to provide a better example of development brownfield in the region.

Figure 02.27 Photo of exposed slags

Figure 02.26 Photo of the lost marsh and the oil tank farm, March,07,2015

Inventory+analysis

opportunities of surrounding road

The site is surrounded by three roads: Highway 912, Calument Avenue and East 128 Street. According to the following traffic data, potential entrances of the site can be located.

Average daily traffic data

1. Highway 912: 68,370 cars per day

Highway 912 has much traffic everyday, which means the south side of the site has a lot of noise pollution and air pollution. Because of this, the highway and major on-site programs should have a buffer between them that would reduce noise pollution and air pollution.

2. Calumet Avenue: 16,618 cars per day

Calumet Avenue has a ramp to connect the Highway 912, so that a new entrance will add pressure to the road.

3. E128st: 8,754 cars per day

Compared to the other roads, East 128 Street has less traffic per day. It also has an existing site entrance along the road. Therefore, the best location for site entrance is located on the East 128 street. Considering community access, a new entrance can also be opened to the surrounding communities.

road

entrance

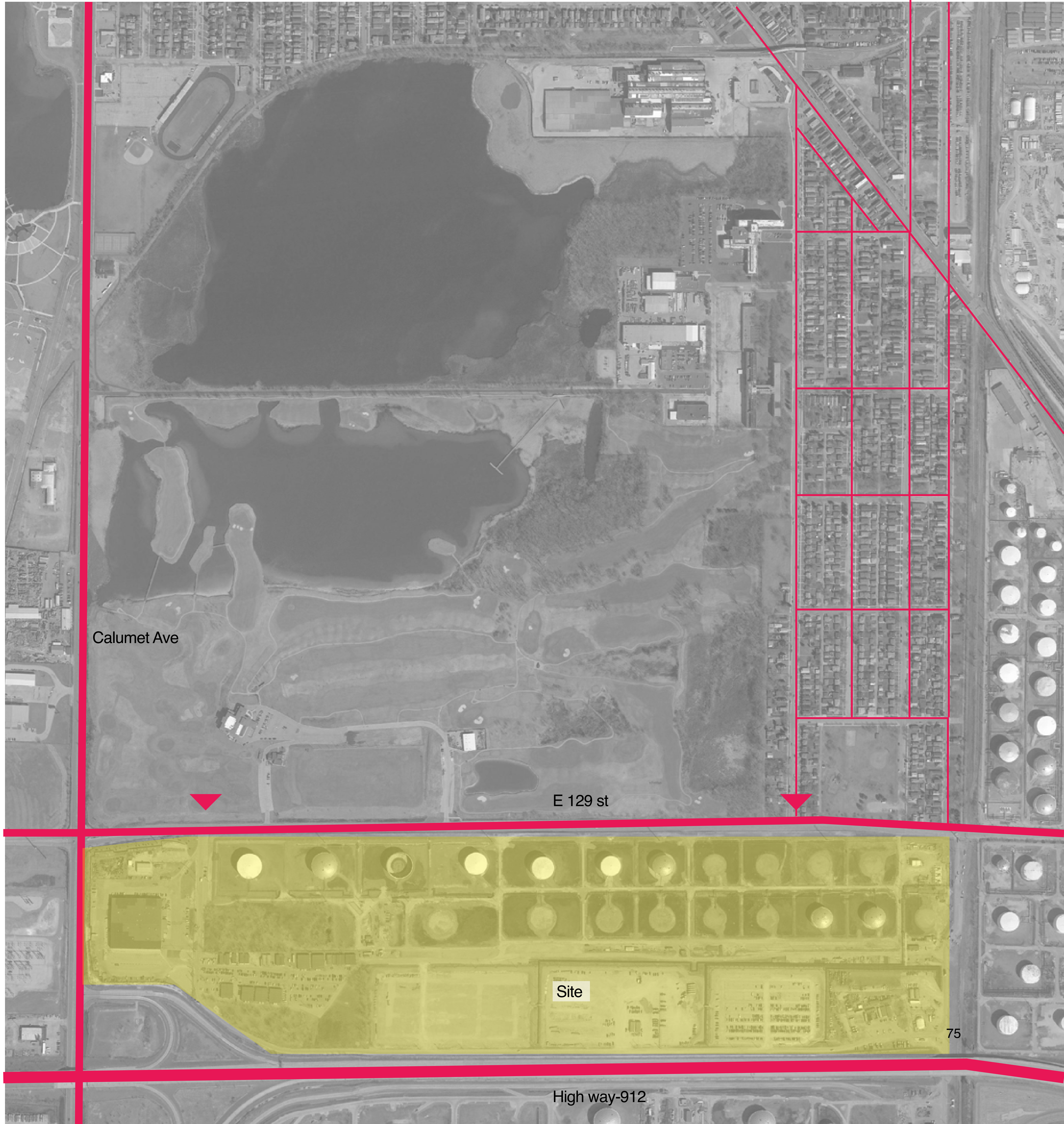


Figure 02.28 Site context of the road system

Figure 02.29 Aerial photo of the site 2015 (google earth).

Site inventory+analysis

3. opportunities of on-site elements.

The study is focusing on finding opportunities to practice the ice cooling system on the site through analysis the site inventory.

The major elements on site:

1. Existing buildings
2. Circulation
3. Vegetation
4. Drainage
5. Oil tanks
6.Slags

Site inventory+analysis
on-site

Figure 02.30 Aerial photo of the existing building

Existing buildings:

The site has 33 warehouses. The strategy of building development is based on the buildings' characteristics to adaptively reuse the warehouses to service the creative project.

The largest building on the site is a 300 by 300 feet warehouse. It is proposed herein to be reused as a visitor center and local industry history museum.

The largest building group has 18 buildings. It is built on a 6 acre hard surface. The area is adopted as an infill development strategy to develop a commercial area for the vistors.

The smaller building group is located near the abandoned rail line. It is proposed herein to be a train station and maintenance houses.

Those existing buildings are also providing a basic cooling energy consumption that guide the cooling energy production program development on the site.

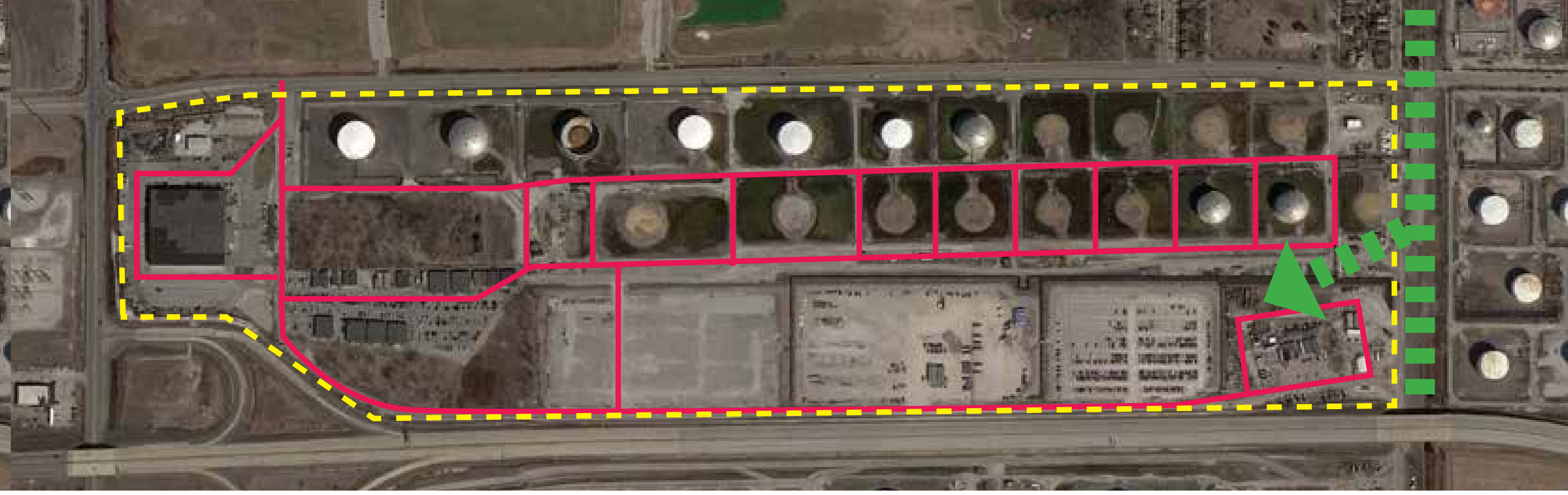


Figure 02.31 Aerial photo of the existing circuation system

abandoned rail line
existing circulation

Site inventory+analysis
on-site

Circulation:

The abandoned rail line functions as ice resource transportation from Lake George to the site.

The existing circulation system is highly efficient.

For the creative project, most of the existing road is reused for the site public transportation.

Site inventory+analysis
on-site

Figure 02.32 Aerial photo of the vegetation

Vegetation:

The site has two groups of trees. The southside trees will be expanded eastward and restored to a riparian forested marsh (Figure 02.35). The forested marsh will be a green buffer that reduces noise pollution and air pollution from the highway. Also, it will function as a water purification hub where runoff and melted ice will be collected.

Figure 02.33 Some native plants on the lost marsh

Figure 02.34 Native plants on the oil tank farm

Figure 02.35 The site dainage

Figure 02.36 A basin on the site

Site inventory+analysis
on-site

Drainage

To keep the liquid chemical safely above ground, the north site is graded by following the above ground storage design guidelines. The south site is considered as a flat parking space.

Each tank is located in a single basin. The basin is designed for fire prevention and leaking prevention. The volume of a basin should be a minimum of 100% of the tank volume, plus the precipitation from a 24-hour, 25-year storm event.

> “ Separation distances between the nearest tanks located in separate dykes shall not be less than the diameter of the larger of the two tanks or 30 meters, whichever is more. All process units and dyked enclosures of storage tanks shall be planned in separate blocks with roads all around for access and safety.
>
> In a dyked enclosure where more than one tank are located, firewalls of minimum height 600mm were provided to prevent spills from one tank endangering any other tank in the same enclosure (Tankfarm, 2015).”

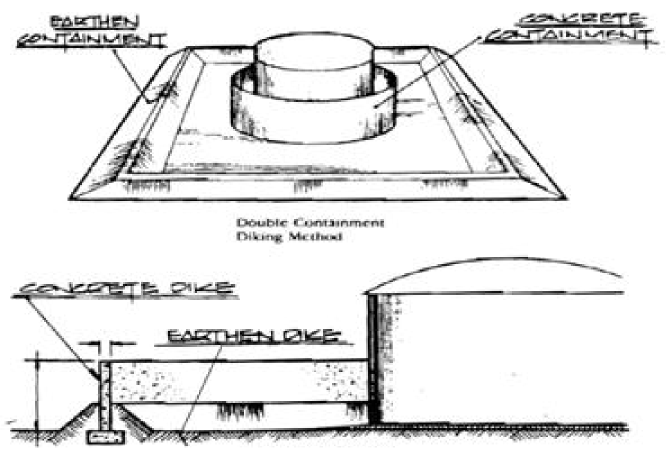


Figure 02.38 Dyke enclosure (Tankfarm, 2015)

The site has 11 existing basins. The average size of a basin is 4 acres. Those basins is designed for runoff management basins, water purification basins or ice marking basins in the creative project.

Figure 02.37 Prototype of water basins as water management units

Forebay
+detention
+water harvest
+water supply

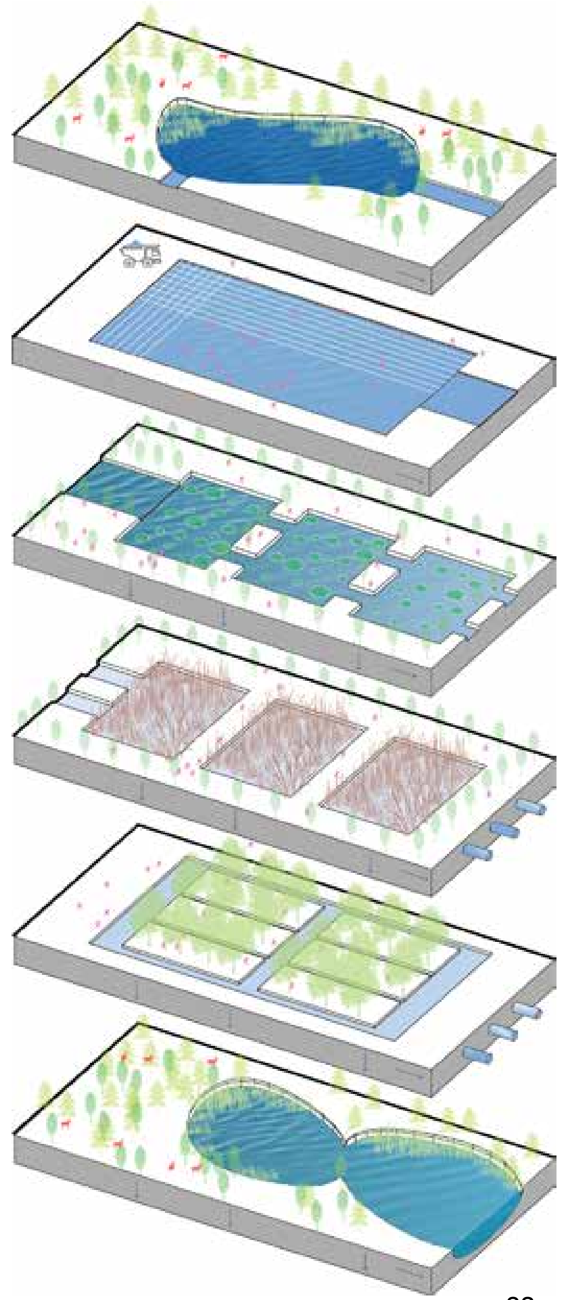
Ice farm
+snow dump area
+ice skating
+gathering space

lily pond
+water treatment

Reeds bed
+insulation supply
+compost supply
+water treatment

Cypress trees grove
+water treatment

Outlet pond
+water supply
+entertainment
+overflow control



Site inventory+analysis

Figure 02.39 On-site oil tanks

Oil tanks

Oil tanks are a strong symbol of the fossil fuel industry in the region. It also represents a part of the local industrial history. The current way to deal with an abandoned oil tank is to deconstruct its steel materials. For the creative project, the oil tanks will be redefined as amenities to the surrounding communities.

The site has 9 existing oil tanks (Figure 02.41). The average size of a tank is 60 feet high and 180 feet in diameter. Those tanks will be adpated to coolth energy infrastructures, green infrastructures, production programs, recreation programs and education programs in the creative project (Figure 02.43). Those programs will be organized into an ice cooling system in the site design phase.

Figure 02.40 0il tank 3631

Figure 02.41 Oil tank 3629

Prototype of oil tanks :

Figure 02.42 shows some potential ideas of reuse existing oil tanks. those idea will be selected in the site design phase.

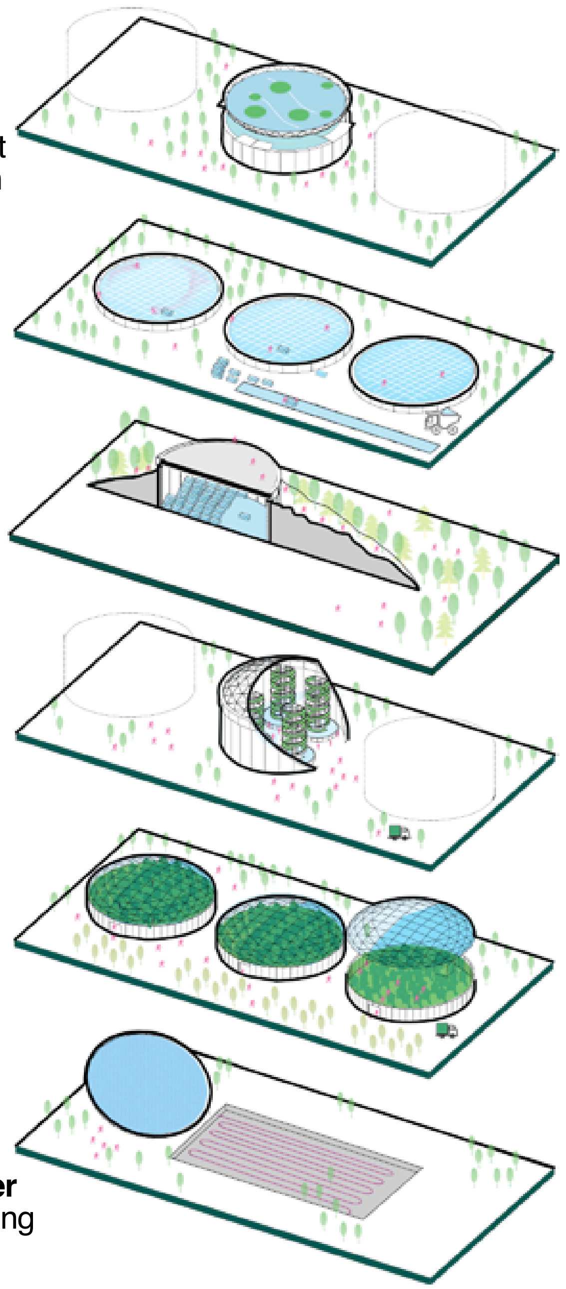


Figure 02.42 Prototype of oil tanks as energy food production units

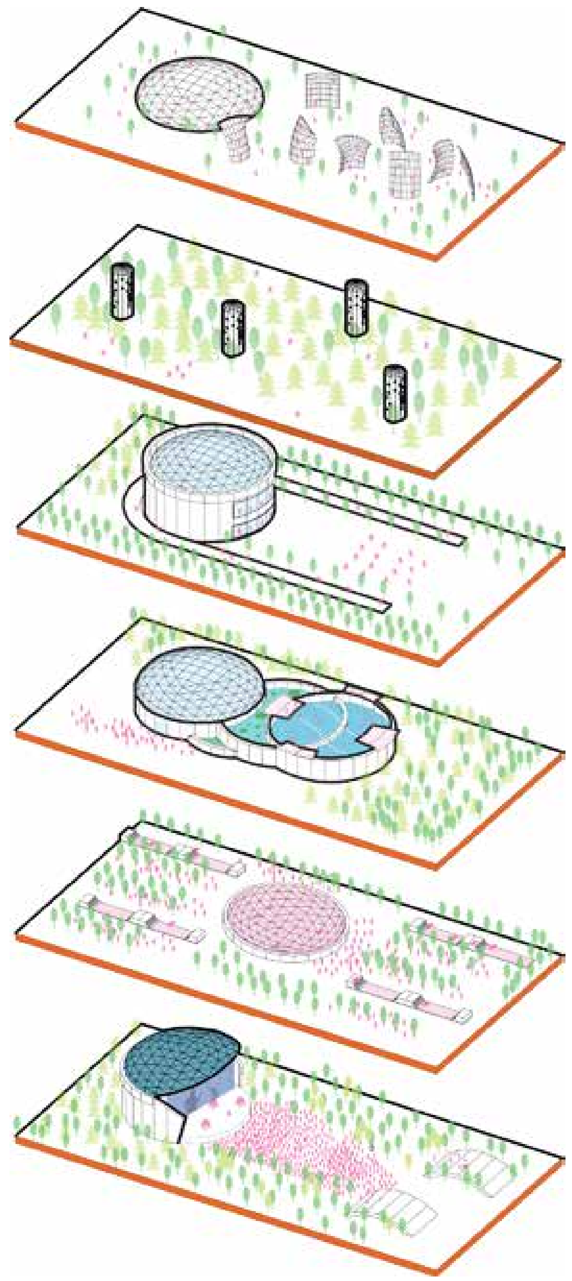


Figure 02.42 Prototype of oil tanks as recreation units

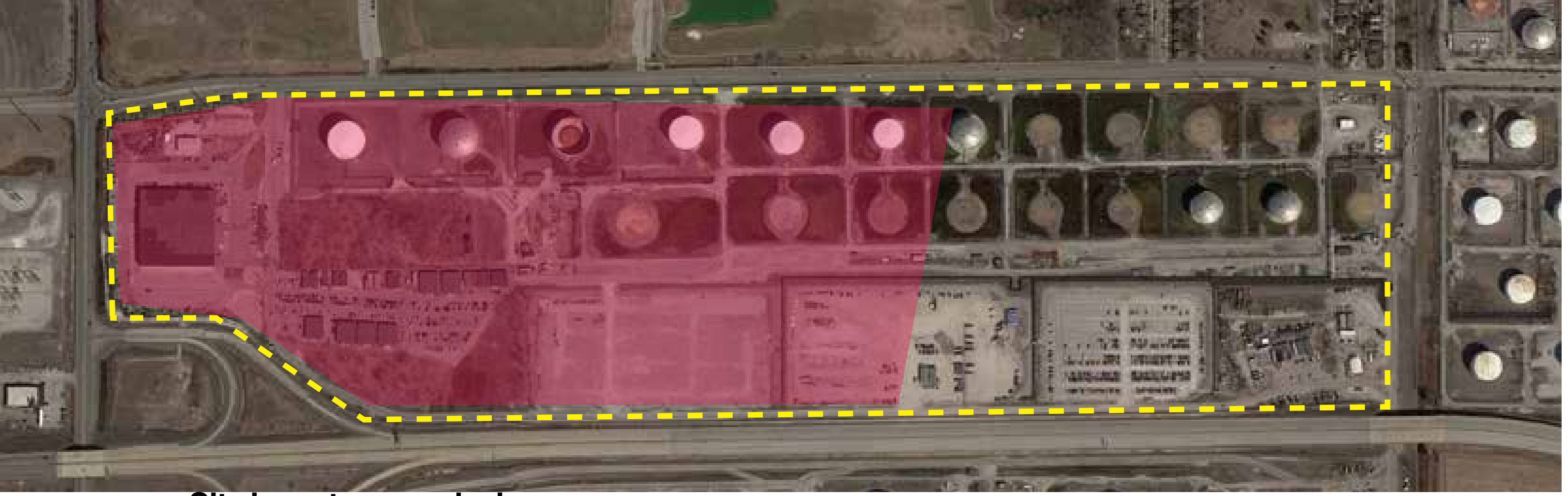


Figure 02.43 Land fill area on the site

Site inventory+analysis

Slags

According to the historical map, half of the site is built on Lake George. The major landfill materials are slags. In most of the project, slags were considered as an useless by product. However, for the ice fuel project, slags are considered an opportunity for site development.

The figure 02.44 shows some examples of reuse slags, such as using slag as an insulation metrial for ice resource preserving, utilizing slags as an infill material to create some construction material for site development, capping the slags to create some landforms on the site, and etc. Those prototypes show various types of solutions to reuse slags in the site redevelopment. these drawings will also help people to see the potential of slag opportunities in the region.

Prototype of slag reuse

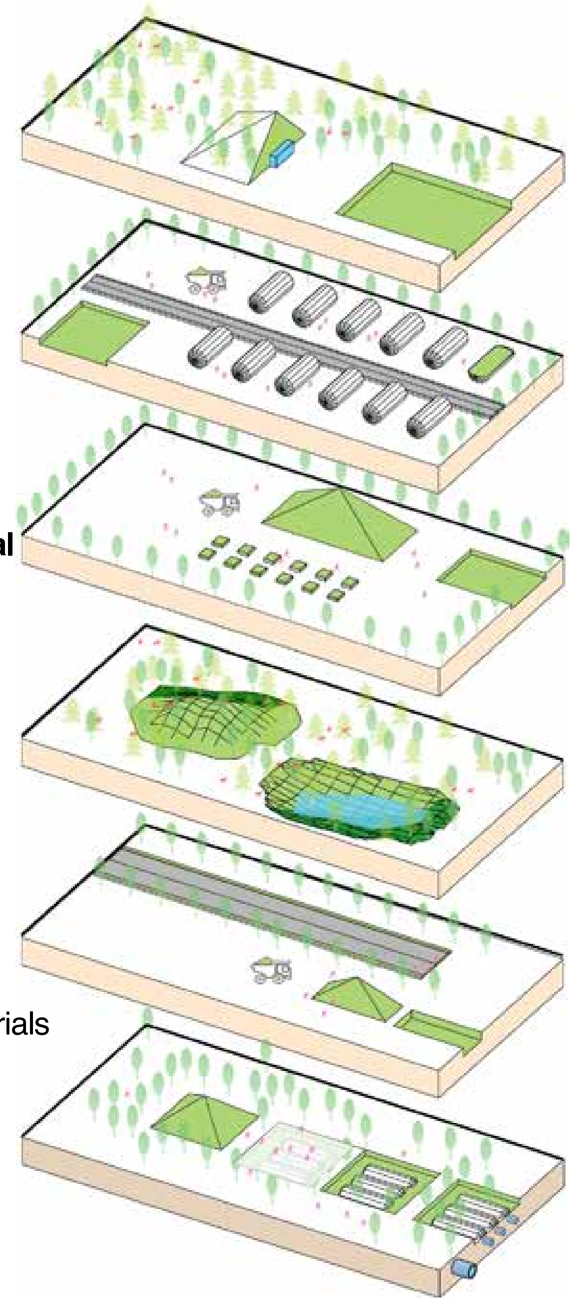


Figure 02.44 Prototype of slag reuse

SITE DESIGN

+design framework
+site plan
+critical components
+site vision

Design framework

The regenerative seasonal cooling system removes polluted ice from the nearby lake in addition to collecting stormwater runoff from the community for on-site ice harvesting. The ice bounty is transported to the ice fuel storage plant, employing an adaptive reuse strategy for existing derelict fuel tanks and slag. The ice storage provides much needed cooling benefits for the site and the local community. As the ice melts, the water will combine with community and site runoff and then will be purified in a series of surface wetlands on the site. Part of the purified water will support on site consumption, such as planting bed irrigation , entertainment and ice production. The rest of water eventually returns to the original lake. Thus the whole system achieves self- sufficiency while incrementally improving the overall water quality. Thus, a strategy of introducing regenerative seasonal cooling system to drive ecological reclamation and education, entertainment and production development is established.

The design is that over the years, the region will be covered by ice cooling system. Also, the regional water quality will become improved and potentially max productivity.

Taking the site as a prototype, this strategy has the flexibility to be applied into communities and larger urban fabrics. Through implementing the seasonal ice cooling system on vacant lots, those abandoned lands will be transformed into district cooling generators, distributing needed cooling and water resource to benefit local communities' entertainment, production and education systems.

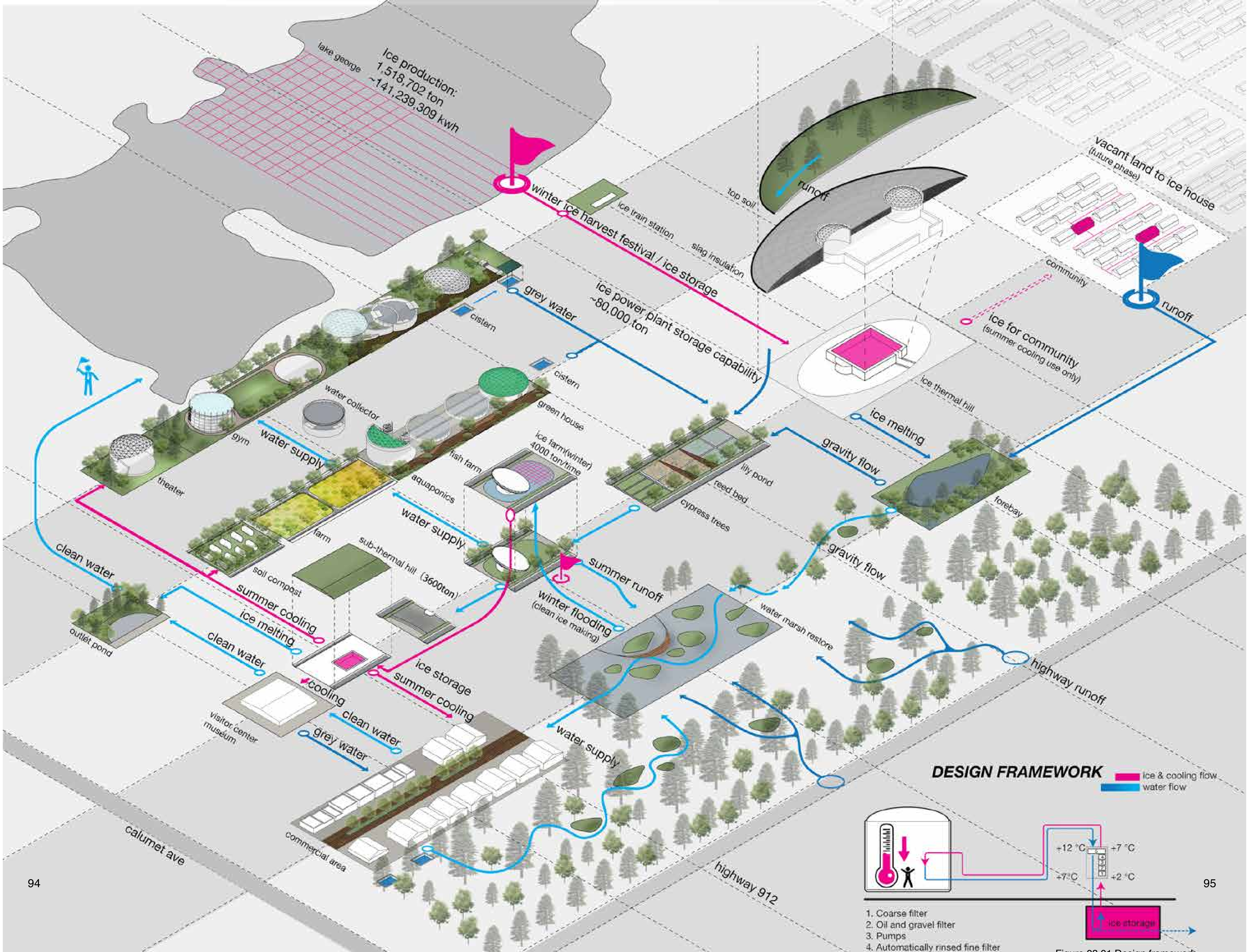


Figure 03.01 Design framework

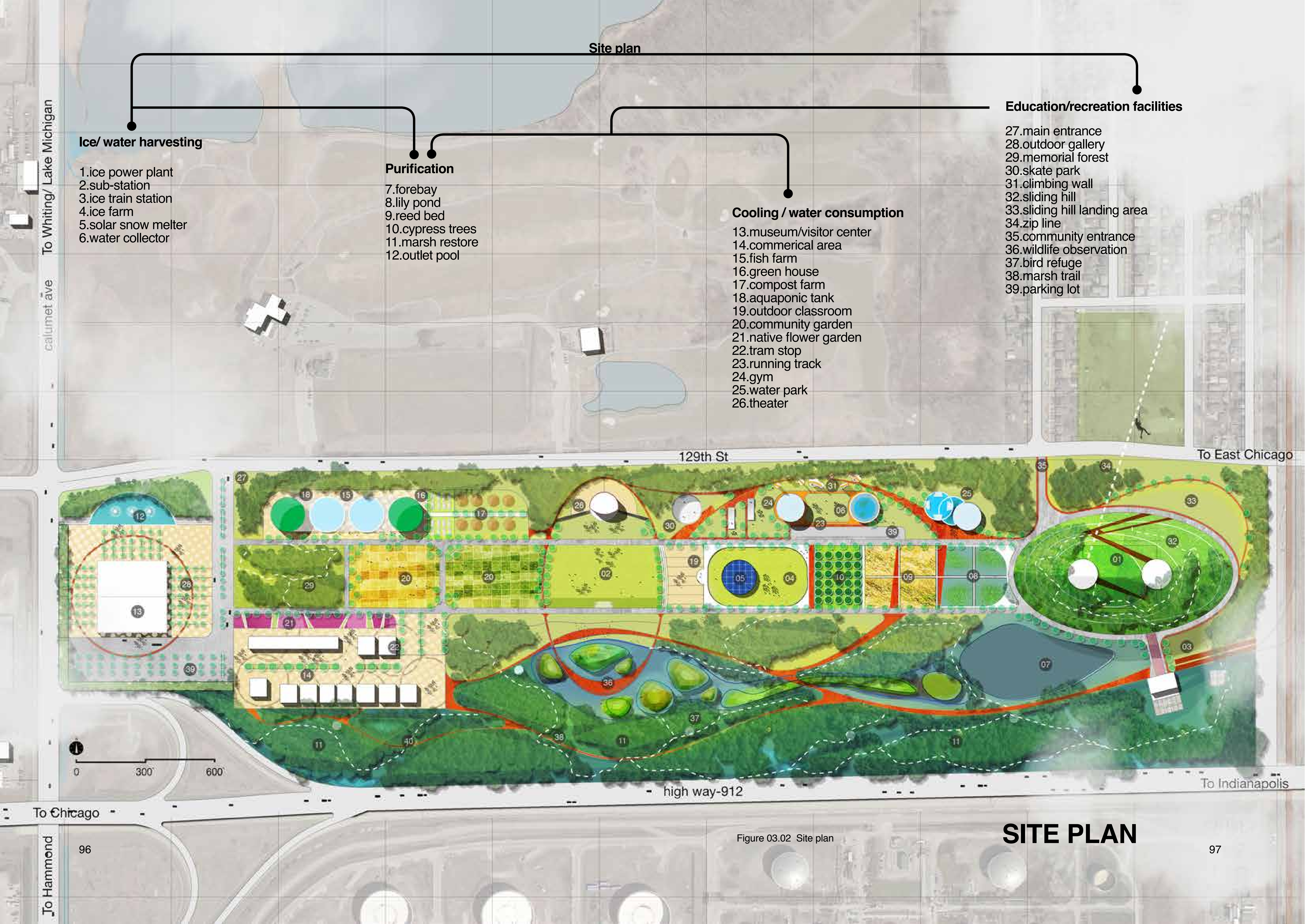


Figure 03.02 Site plan

SITE PLAN

Critical Components

The critical components of on-site programs are categorized into four aspects: ice harvesting and storage, purification, cooling energy and water consumption, and major education points.

1.Ice Harvesting and Storage.

To ensure a stable ice resource supply to the community and the site, the ice is harvested from two resources: Lake George and the on-site ice farm. It will be stored in two on-site spots: ice power plant and sub-station, which both utilize slags as the foundation for landform creation and insulation for ice storage.

Lake George: the lake provides an event place for visitors to practice and experience ice harvesting in the traditional way. Also, it is a natural ice resource for future district cooling system development.

On-site Ice Farm (site plan No.04)**:** this ice farm takes advantage of existing basin landform to produce ice by purposely flooding the basins with water from a nearby retention pond during winter. The ice farm has the capacity of producing over 8000 tons of ice each winter. While during other seasons, it functions as a hub (Figure 03.04) for gathering and ice-skating and a basin for rainwater harvesting and snow-melt. To ensure the ice farm can melt the snow efficiency during winter, a solar snow melter (site plan No.5) is designed to melt the snow dump to water during the day time. The water can refrige into an ice resource at night. Thus, the ice farm can have enough capability to produce ice in alternative ways during the winter(Figure 03.04).

Ice power plant: (site plan No.1) the ice plant storage capacity is designed based on the community yearly cooling consumption. Considering the ice loading and distributing efficiency, the ice

power plant is placed near the rail line and community.

While the power plant looks like a hill (Figure 03.09), it utilizes slags to provides the foundation for landform creation and insulation for ice storage. The elevation changes present an opportunity for recreation programming such as sledding, hiking and zip lines.

Sub-station (site plan No.2) **:** the sub-station is placed in the middle of the site and near the ice farm. The sub station includes above ground space and underground space. The underground space is used as ice storage and ice cooling energy distributing. The above ground space function as an multiple use space,such as playground, gathering space and outdoor theater. The nearby existing oil tank is used as a performance stage that provides opportunities for multiple functions of the sub-station area (Figure 03.05).

2.Purification.

To provide different water purification demonstration experience and improve the water treatment capacity, the purification system is designed with two water trails and green infrastructures including: the water purification demonstration trail and the fresh water marsh restoration trail.

Water purification demonstration trail: this trail is designed as a place to demonstrate ecofriendly water treatment technologies. It includes a lily pond (site plan No.8), a reed bed (site plan No.9) and a water cypress trees plaza (site plan No.10).

Purified water will be stored in the underground cistern for the ice farm and other water consumption. Overflow water will merge into the fresh water marsh (site plan No.11).

Fresh water marsh restoration trail: (site plan No.11) this trail leads one through excavations of the slags landfill, with new topography harnessing natural ecologic processes to improve water quality and restore the lost marsh. With a 75 acres fresh water forested area, it can contain ~112 million gallons of water from harvested ice melt, community runoff, on-site runoff and nearby highway runoff. Through restoration process, soil, vegetation and water have a symbiotic relationship that remediates contamination and buildings a resilient ecosystem (Figure 03.10).

The green infrastructures include: water collector(site plan 06), forebay(site plan 07), outlet pool(site plan 12).

Water collector: (site plan 06). The water collector is created from an existing oil tank. The function of is collector is to harvest and purify rainwater. This water can then be used for ice making, irrigation, and entertainment. (Figure 03.06).

Forebay(site plan 07)**:** the forebay is located on the east side of the site near the ice power plant. The forebay functions as an retention pond that collects the water from the nearby ice power plant and the community's runoff.

Outlet pool(site plan 12): The outlet pool is located on the west part of the site. It is a water transfer station that collects the overflow water from the fresh water marsh wetland to Lake George.

3.Cooling energy and water consumption

The cooling energy and water consumption occur in irrigation activities, recreation programs and future food production programs. The reasons to have these programs are not only because they improve local community life quality in diverse ways but also they showcase a symbiotic relationship

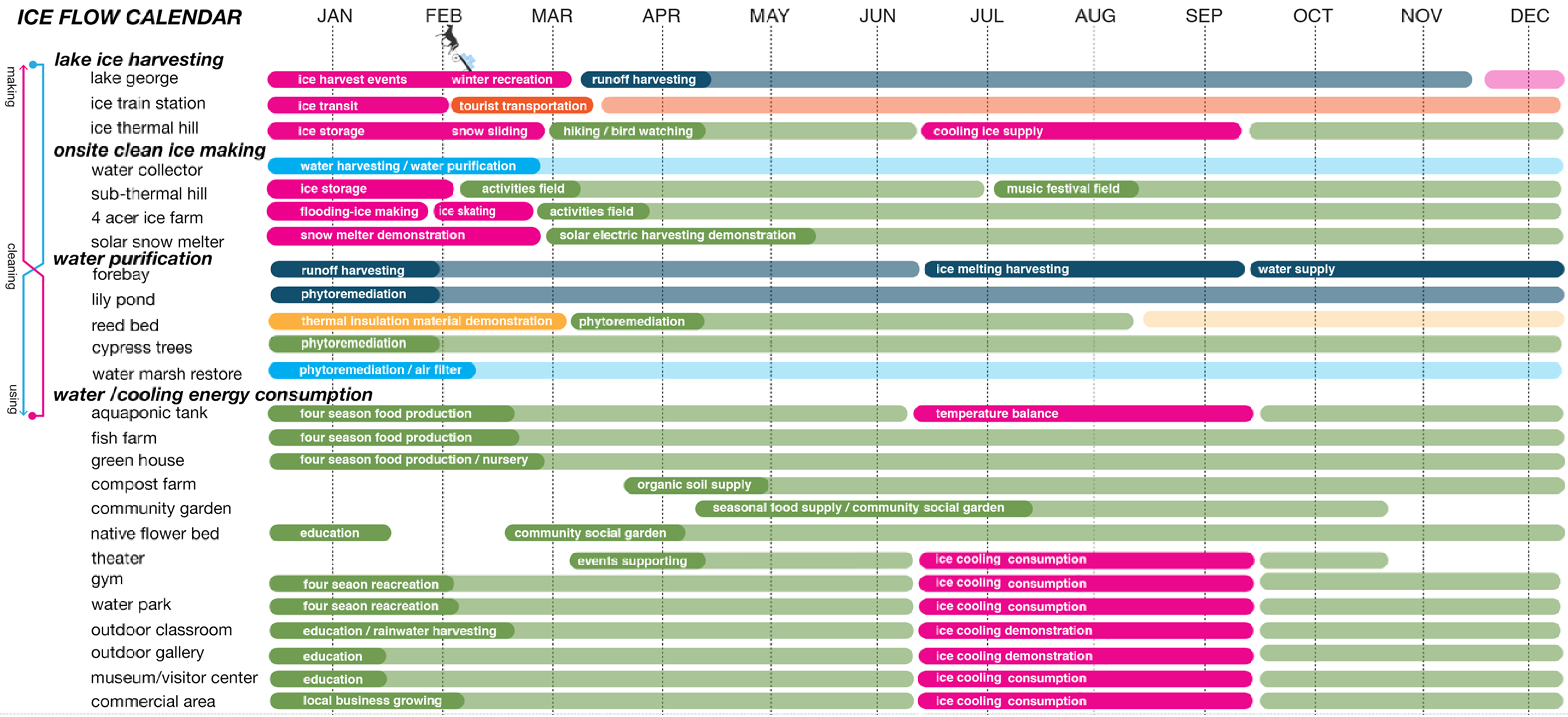
between the regenerative cooling system with other systems.The ice fuel project as a comprehensive prototype has the flexibility to be applied into communities and larger urban fabric.

4. Major education points.

The major education points include outdoor classrooms (site plan 19), (Figure 03.07) outdoor gallery (site plan 28), museum and visitor center (site plan 13) (Figure 03.08). Those facilities bring together a narrative about ice harvesting history and story of ice cooling systems.

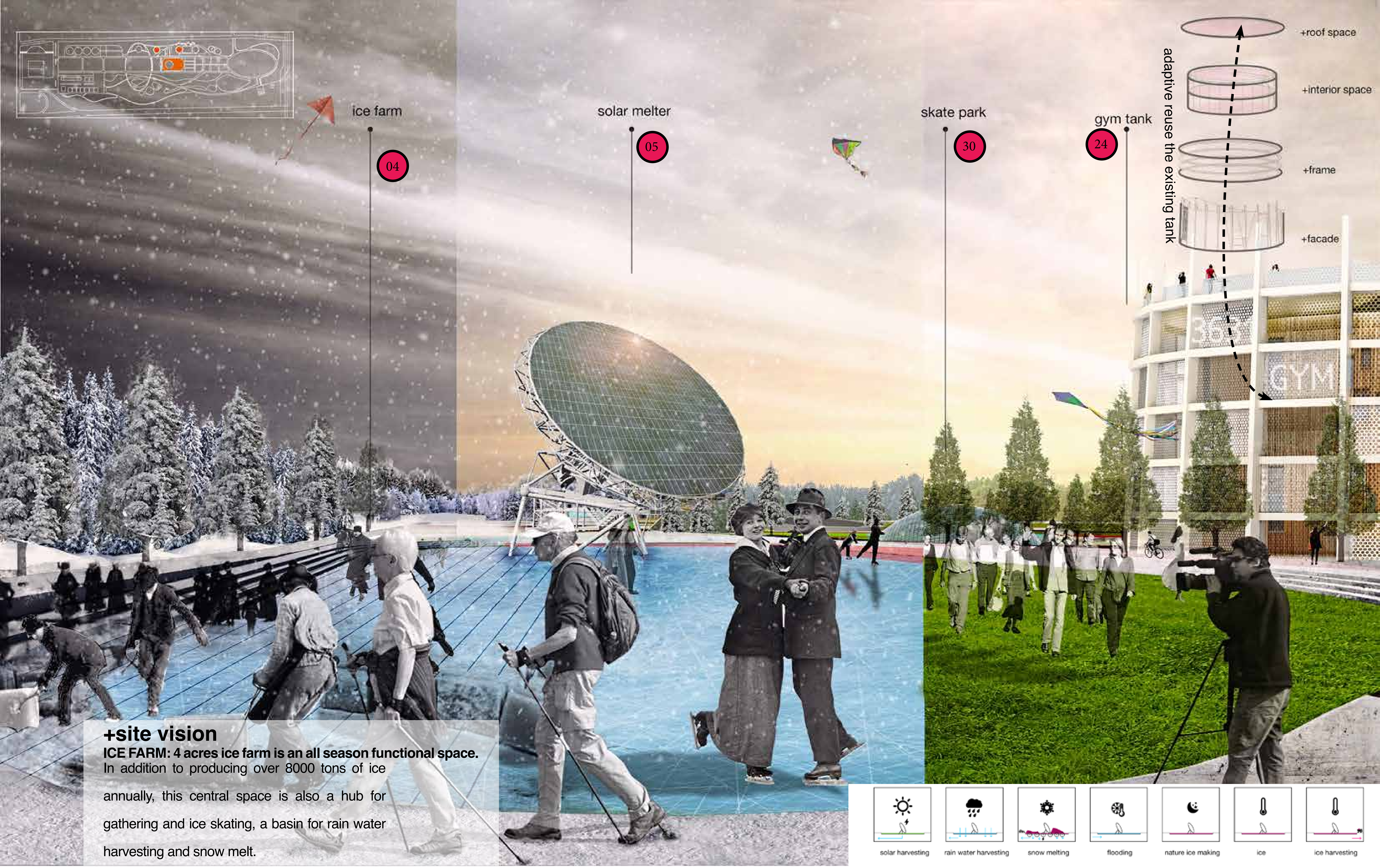
Notes:

The site design is a comprehensive planning. Because a limit time, the critical components are just covered the major programs in the creative project.



Figue 03.03 The programs calendar

The ice energy education park is a all season fuctional site.



+site vision

ICE FARM: 4 acres ice farm is an all season functional space. In addition to producing over 8000 tons of ice annually, this central space is also a hub for gathering and ice skating, a basin for rain water harvesting and snow melt.

Figure 03.04 Ice farm

+site vision 26

OUTDDOOR THEATER: oil tank adaptive reuse

Figure 03.05 Outdoor theater

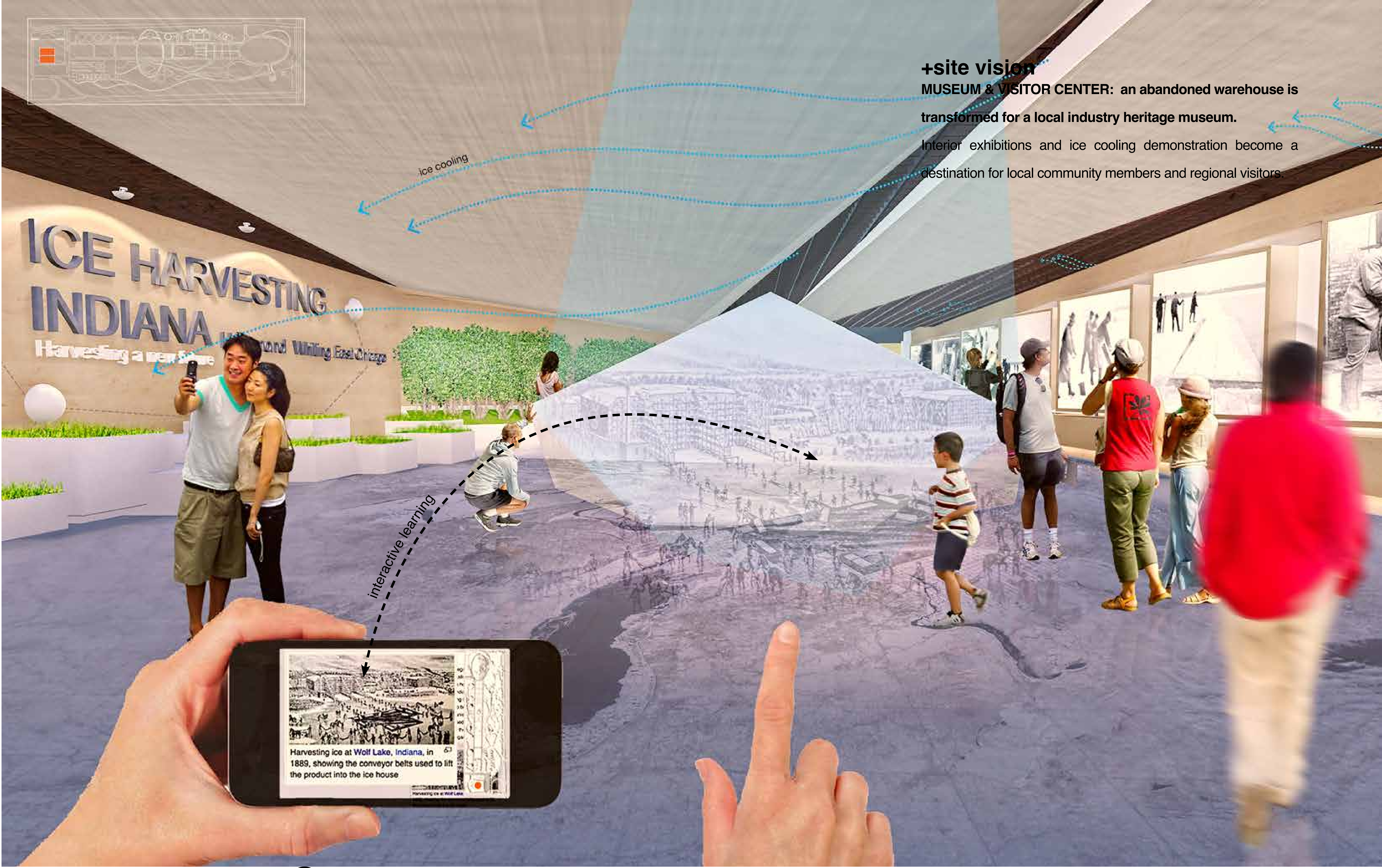
+site vision

RECREATION FIELD: remnant oil tanks repurposed as a community amenity.
Deconstructed tanks are refabricated to support green infrastructure and various recreation programs.
The ice cooling system provides comfortable cooling mist for the visitors.

 Figure 03.06 Recreation field

Figure 03.07 Outdoor classroom

19



+site vision

MUSEUM & VISITOR CENTER: an abandoned warehouse is transformed for a local industry heritage museum.

Interior exhibitions and ice cooling demonstration become a destination for local community members and regional visitors.

Figure 03.08 Ice harvesting museum 13

Figure 03.09 section a-a1

SECTION a-a1:

Slag provides the foundation for landform creation and insulation for ice storage.

The elevation changes present an opportunity for recreation programming such as sledding, hiking and zip lines.

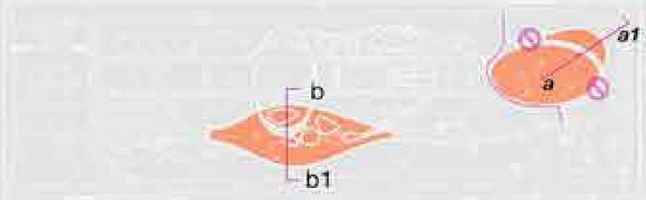
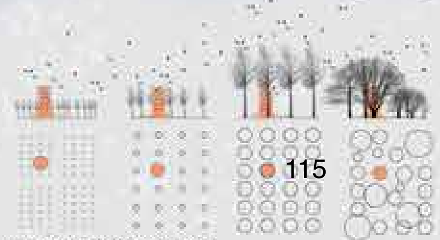


Figure 03.10 Section b-b1

SECTION b-b1:

Harvested ice for the cooling energy melts and filters through a series of ecosystems on the site.

Through this process, soil vegetation and water have a symbiotic relationship remediates contamination and building a resilient ecosystem.


growth strategy for
bird refuge tanks and riparian forested marsh

+site vision

REGIONAL OPPORTUNITY :

Ice harvesting was deeply connected to the great lakes region. Currently, the history of ice harvesting is melting away.

Looking to the future, extreme winter temperature means greater winter energy, greater opportunity for harvesting ice and quality of life.

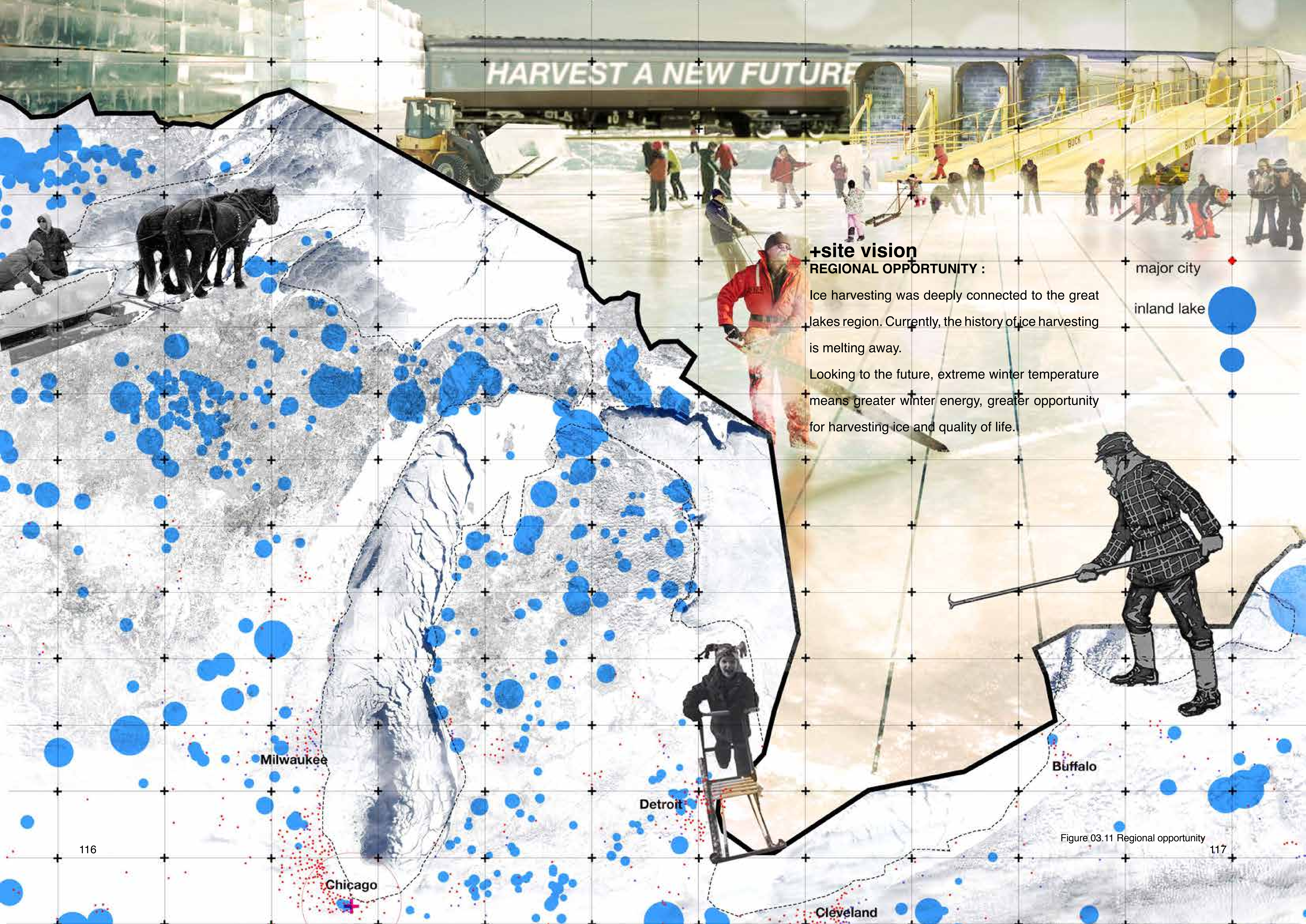


Figure 03.11 Regional opportunity

This ice fuel project proposes a 150-acre brownfield redevelopment to address the complex issues of the region with historic practices reactivated through the adaptive reuse of relic infrastructures. The ice industry resurrects a historic cultural and economic practice. The project serves as a trigger for community and local economy in a landmark recreation landscape that is resilient, healthy and productive.

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